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CHAPEL HILL, N. C., U. S. A.

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A STUDY OF THE ACTION OF VARIOUS DIURETICS IN URANIUM NEPHRITIS[1]

By Wm. deB. MacNider.

In a recent anatomical study (1) of the nephritis produced in the dog by the use of various nephrotoxic substances it has been shown that these substances vary to some extent in the degree of their selective affinity for the different kidney tissues. Arsenic, for example, has a striking affinity for the blood vessel tissue of the kidney; while potassium dichromate causes an involvement of the epithelial element of the kidney much earlier than does any of the usually employed nephrotoxic substances.

Uranium nitrate, a substance which has frequently been employed to produce experimentally a nephritis, in its avidity for the different tissues of the kidney, is not so selective in its action as are the poisons just mentioned.

If uranium be given in large doses subcutaneously, or if smaller quantities be used and the nephritis be allowed to persist for some days, the nephritis which it induces with such a technique is more tubular than vascular. If, on the other hand, small quantities are employed, 5 to 10 mgs. per animal, and if the nephritis be terminated early, the reaction on the part of the

[1] Presented in abstract before the Society for Pharmacology and Experimental Therapeutics, Baltimore, December 27, 1911. Reprinted from *The Journal of Pharmacology and Experimental Therapeutics*, Vol. III, No. 4, March, 1912.

kidney is largely vascular. We possess, therefore, in uranium a nephrotoxic substance which, when appropriately administered, is competent to produce the two main types of nephritis. For this reason uranium was the nephrotoxic substance selected to use in the production of nephritides of different severity, in which one or both elements of the kidney concerned in the formation of urine were functionating pathologically.

By the use of such a substance which produces primarily a vascular, and later a tubular nephritis, it was hoped that by studying the physiological response of the kidney at these stages of its pathological reaction, it might be determined which element of the kidney in a nephritis was most concerned in determining the quantitative output of urine. With this object in view in this study diuretics have been employed which effect both the vascular and the epithelial elements of the kidney.

In the anatomical study of experimental nephritis which has been previously referred to, the nephrotoxic substances employed were potassium dichromate, sodium arsenate, cantharidin and uranium nitrate. During the course of this investigation it was noted that there existed a fairly clear cut correllation between the degree of epithelial involvement in a given nephritis and the total output of urine; whereas, on the other hand, no such histological correllation could be made, within certain limitations, between the severity of the vascular pathology and the output of urine. For example, a nephritic animal with a normal urine flow, or a polyuria, would show a vascular reaction which histologically would be similar to the vascular pathology in an anuric animal. The associated epithelial reaction in such stages of a nephritis differed very widely. In the early nephritides with a normal output of urine, or a polyuria, the epithelial involvement was slight or absent. In some of the experiments, especially those conducted with uranium, the epithelium appeared to have undergone a shrinkage. In the later stages of the nephritis when the output of urine had been reduced or an anuria had developed, the epithelium, and especially that of the convoluted tubules invariably showed marked alterations. The epithelial changes varied with the severity of the nephritis.

The earlier degenerations consisted in cloudy swelling and vacuolation, while the later changes were principally an epithelial desquamation, usually preceded by necrosis.

In these late nephritides the swelling of the epithelium was frequently decidedly noticeable and was sufficient either greatly to encroach upon or completely occlude the lumen of the tubules.

The present physiological study of the nephritic kidney has been undertaken to determine, if possible, the part played by the vascular and by the epithelial pathology of the kidney in influencing the output of urine, and to determine whether or not the vascular mechanism of the kidney is physiologically responsive in a nephritis in which there is evidence of epithelial involvement and but little histological evidence of vascular injury.

REVIEW OF LITERATURE

The two most important recent contributions to the study of acute experimental nephritis are those by Schlayer (2) and Hedinger and by Pearce (3), Hill and Eisenbrey.

These investigations were conducted with the same general object in view and are principally concerned with the physiological response of the nephritic kidney.

Schlayer and Hedinger studied the vascular reaction of the kidney in both the glomerular and the tubular types of nephritis. For their studies in the vascular type of nephritis they employed as kidney poisons, cantharidin, arsenic and diphtheria toxin, and for the tubular type potassium chromate and corrosive sublimate.

The investigation by Pearce, Hill and Eisenbrey was also principally concerned with the vascular reaction in acute nephritis. The authors were able to distinguish types of nephritis in which either the tubular or the vascular changes predominated. They were not able to conclude, however, that a given poison produced an exclusively tubular or vascular injury. Potassium chromate, corrosive sublimate and uranium nitrate, caused extensive tubular injury and in the early stages of the nephritis showed no evidence of vascular injury except physiologically. When physiological methods were employed they were able to demonstrate in the early stages of the nephritis

an exaggerated contraction and dilatation of the vessels and also an increased diuresis. Arsenic and cantharidin acted as vascular poisons and produced but little injury to the tubules. Both of these poisons tended to cause an anuria which was characterized by minimal contraction and dilatation of the renal vessels and little or no flow of urine. Finally, in this investigation two types of late tubular nephritis are described: one anuric and accompanied by gastro-intestinal symptoms; and the other polyuric until the time of anesthesia.

In addition to these two investigations which are principally concerned with the physiological response of the kidney, pathological studies of the kidney in a uranium nephritis have been made by several investigators.

Heineke and Myerstein (4) were able to demonstrate a marked vascular disturbance in the kidney from uranium in addition to a pronounced action on the renal epithelium; while Dickson (5) in an extensive series of experiments in which the guinea pig was the animal employed came to the same conclusions.

Christian (6) in his work on uranium nephritis in which the vascular pathology was studied, described as developing in the capillaries of the glomerulus, oval or irregular homogeneous droplets 0.5 to 4 microns in diameter. Similar structures have been observed in several of the experiments in the series of animals which will be presented in this study.

The work of Schirokauer (7) on the uranium nephritis of rabbits is of special interest on account of the associated anasarca.

DISCUSSION OF THE TECHNIQUE EMPLOYED IN THE EXPERIMENTS

In conducting the experiments the dog was the animal constantly employed. A total of twenty-three animals were used. The animals were free from disease and their general nutrition was apparently normal.

For three days prior to the experiments the animals were kept in metabolism cages, fed on beef and hard bread and given once a day by stomach tube a known and constant quantity of water. The quantity of water varied with the size of the ani-

mal. During the period of preliminary observation the urine was collected daily, measured and studied qualitatively and microscopically. The existence of a naturally acquired nephritis was excluded. Two of the animals showed the presence of albumen and erythrocytes in the urine but no casts.

At the end of three or four days, after the preliminary data had been obtained, the animals were given from 5 to 10 mgs. of uranium nitrate subcutaneously. The frequency with which the injections were repeated was determined by the severity of the nephritis produced by a given injection and by the stage of the nephritis that was desired in which to study the action of the different diuretic substances. Such a method of regulating the quantity of nephrotoxic substance is more accurate, so far as the reaction on the part of the kidney is concerned, than can be obtained by using a constant quantity of the kidney poison per kilogram of body weight, since different animals vary very greatly in their response to the same quantity of the poison.

Usually within twelve or twenty-four hours after the initial injection of uranium the animals had developed a well-marked nephritis.

Occasionally on the first day of the nephritis, and almost invariably by the second day, the animals developed a pronounced glycosuria. The quantitative output of albumen was not determined. Quantitative sugar determinations were made with both Fehling's and Purdy's quantitative reagents. These determinations showed that the output of sugar in a twenty-four hour specimen of urine varied from 0.25 to 3.22 per cent.

After the production of the nephritis the animals were anesthetized with either morphine-ether or Gréhant's anesthetic.[1]

The following operative technique was constantly employed.

A tracheal canula was tied in place and connected with the ether bottle to be used in case additional anesthetic was necessary during the experiment.

[1] *Gréhant's Anesthetic.* The animal is given ¼ cc. per kilogram of a 4 per cent solution of morphine. This is followed in half an hour by 10 cc. per kilogram of the following mixture: Chloroform, 50 cc.; alcohol and water, each 500 cc.

The carotid pressure was recorded in the usual way, and a relative idea of the heart volume was obtained along with the pressure tracing by means of a Hürthle manometer.

The left kidney was surrounded by a rubber bag filled with water, and the kidney with its surrounding water cushion placed in a copper oncometer. The oncometer communicated by means of a rubber tube with a water manometer which registered on an arbitrary scale graduated in millimeters the increase or the decrease in the volume of the organ.

Into each ureter was placed a ureter canula. Observations of the urine flow were made only from the right kidney, on account of the fact that the flow from the left kidney was possibly influenced by the mechanical disturbance necessarily associated with the use of the oncometer.

The various diuretic solutions were given intravaenously through the femoral vein, due care being taken of their temperature.

The experiments were of such a nature that they would necessarily require considerable time for consecutive observations of the action of the different diuretics. On this account it seemed advisable to employ some method to maintain a fairly constant body temperature. For this purpose a copper water box was used, similar to the ones employed in Sollmann's laboratory. The upper surface of the box is concave and holds a wooden rack in which the animal is placed. With such an apparatus the animal's body temperature can be fairly accurately maintained.

At the termination of the experiments, the kidneys were at once removed and tissue fixed for microscopic study in both corrosive-acetic and in formaline.

Five of the twenty-three animals employed in this investigation were either purposely or accidentally killed before or at the commencement of the anesthetic. Kidney tissue from these animals was fixed for histological study.

In the remaining eighteen animals the physiological response of the nephritic kidney was studied under the influence of:

Caffeine........1-2 cc. of a 1 per cent solution per kilogram
Theobromine....1-2 cc. of a 1 per cent solution per kilogram
Digitalin..............................1 mg. per kilogram
Sodium chloride solution....0.9 per cent, 10 cc. per kilogram

COURSE OF THE EXPERIMENTS

The average daily output of urine of each animal was determined at the end of the third day, during which time the preliminary observations were being made. Following the injection of uranium the daily output of urine was ascertained and compared with the average daily output by the animal prior to the use of uranium.

Three of the animals were used experimentally after they had developed a nephritis but before the development of a glycosuria. The daily output of urine by these nephritic and non-glycosuric animals showed a moderate increase as follows. The urine from the different animals increased respectively from 278 to 318 cc., from 392 to 440 cc. and from 386 to 358 cc. The urine showed qualitatively a pronounced reaction for albumen, and microscopically hyaline and granular casts and erythrocytes.

The remaining animals were used experimentally after the development of a glycosuria. In each instance, with the development of a glycosuria the output of urine at once enormously increased. For example, in experiment 1, in which the animal was receiving daily 350 cc. of water, the average daily output of urine for three days prior to the uranium was 385 cc., while with the development of a nephritis and an accompanying glycosuria the urine increased on the first day to 620 cc. and on the second day to 750 cc.

Again, in experiment 8, in which the animal was receiving 500 cc. of water daily, the average output of urine prior to the uranium was 513 cc., while following the uranium with the development of a nephritis and a glycosuria the output of urine increased to 1310 cc.

This increase in the output of urine was not an occasional occurrence, but it developed in each animal that was allowed a sufficient time to develop a glycosuria. These polyuric and nephritic animals were anesthetized by one of the methods pre-

viously mentioned. Within thirty-four minutes to an hour and a half after the commencement of the anesthetic, the output of urine from these excessively diuretic animals was either very greatly reduced, reduced to a condition bordering on an anuria, or an anuria had developed, which in six of the animals persisted throughout the experiment, uninfluenced by the diuretics which were employed.

This pronounced reduction in the output of urine after the anesthetic is equally as striking as is the increase in the output of urine after the animals have developed a glycosuria.

Experiment 20 is used to illustrate these observations. The animal was receiving 500 cc. of water daily. The average output of urine for the three days prior to the uranium was 464 cc. The animal was given subcutaneously one injection of uranium of 10 mgs. The animal rapidly developed a nephritis and a glycosuria, and the urine increased to 1018 cc. At the time of the experiment 294 cc. of this urine was found in the bladder, which shows quite clearly that the animal was diuretic until the time of anesthesia. The experiment lasted four hours and during this time the animal was in a perfectly satisfactory physiological condition. The general blood pressure varied between 93 and 108 mm. of mercury and the renal vessels were physiologically responsive to caffeine, theobromine and 0.9 per cent salt. Not a drop of urine was voided.

This experiment, associated as it is with others which give identically the same results, shows a definite relation between the polyuria and the development of glycosuria. Secondly, it shows an equally intimate connection between the use of an anesthetic and the development of an anuria. The polyuria in uranium nephritis and the influence of the anesthetic in reducing the output of urine has been observed by both Schlayer (2) and Pearce (3). Pearce attributes the anuria to a "decreased glomerular permeability" and makes a similar suggestion to interpret the results obtained by Schlayer. So far as I have been able to learn these authors make no note of the association of the polyuria with the onset of the glycosuria.

THE EFFECT OF DIURETICS IN URANIUM NEPHRITIS

To facilitate the study of the effect of the different diuretics the experiments have been classified into groups, *e. g.,* the Anuric, Practically Anuric and Diuretic Groups.

Anuric group

Six experiments are included in this group. In all six of the animals caffeine, theobromine, and digitalin were employed as diuretics and in four of the animals 0.9 per cent salt was also used. None of these agents had any effect in reëstablishing a flow of urine. This failure cannot be attributed to either a failure on the part of the diuretics to increase and maintain an adequately high general blood pressure for urine secretion, or to a failure in the vascular response of the kidney. The following experiment will serve well to illustrate these points:

Experiment 23. The animal's general blood pressure at the commencement of the experiment was 104 mm. of mercury and at the termination 107 mm. Caffeine produced a rise in arterial pressure of 4 mm. of mercury and a rise in the oncometer of 27 mm. (water manometer). Theobromine produced a rise of 7 mm. in general pressure, and a rise in oncometer pressure of 59 mm., digitalin a rise of 18 mm. in arterial pressure and 20 mm. in oncometer pressure, while 0.9 per cent salt caused no rise in general blood pressure, but a rise of 15 mm. in oncometer pressure. The animal remained anuric throughout the experiment.

Practically Anuric group

Falling in this group are experiments 6 and 11. They represent animals which are not absolutely anuric but which show a gradual decline in the flow of urine which is but slightly influenced by the diuretics.

The first animal of this series, experiment 6, prior to the anesthetic had an output of urine of 810 cc. Following the anesthetic an anuria developed for two hours, although during this time a rise of blood pressure of 14 mm. of mercury and of oncometer pressure of 12 mm. of water was obtained from caffeine and a rise of 10 mm. in general pressure and of 12 mm.

in oncometer pressure from theobromine. During the last half hour of the experiment, under the effect of 0.9 per cent salt the arterial pressure rose 17 mm. and the oncometer pressure 20 mm. The urine filled the ureter canula and a few drops were discharged into the receiving flask.

Experiment 11 followed the same general course. Prior to the anesthetic the animal was highly polyuric. Following the anesthetic the output of urine for the first half hour period was 2 cc. The urine flow then decreased, although the animal showed the usual physiological response to caffeine and theobromine. During the final half hour period of the experiment the flow of urine had been reduced to two drops. The experiment demonstrates a continuance of those changes, whatever they may be, which lead to an anuria, and which commence with the administration of the anesthetic, and in this instance have progressed, uninfluenced by the employment of diuretics.

Diuretic group

In the animals classified as diuretic, the term is used relatively. With few exceptions these experiments were terminated artificially during a period of diuresis. Such a termination does not exclude the possibility of the animal later becoming anuric as was illustrated in the previously described experiment.

The following experiments are representative of this group:

Experiment 16. The animal had a pronounced nephritis, was polyuric and had developed a glycosuria. Following Gréhant's anesthetic the animal became anuric for fotry-five minutes. Following the use of caffeine, with a rise of arterial pressure of 5 mm. of mercury and of oncometer pressure of 8 mm. the urine flow was reëstablished and during the half hour period following the use of caffeine the flow of urine was 1.5 cc. Under theobromine without a rise in arterial pressure but with a rise in oncometer pressure of 4 mm., the flow of urine increased to 3 cc. in a half hour period. With digitalin which produced a rise in arterial pressure of 10 mm. and in oncometer pressure of 8 mm. the urine flow increased to 3.3 cc. in a half hour interval.

In three of the experiments of this series 0.9 per cent salt was used. With the salt solution the greatest degree of diuresis was produced and this diuretic effect from the salt was more constant than that from the other diuretics in this type of nephritis.

In experiment 19, the flow of urine in the half hour period prior to the use of salt solution was 0.9 cc. Following the salt with a rise in arterial pressure of 14 mm. and in oncometer pressure of 49 mm. the urine increased 1.7 cc.

In experiment 17 with a flow of urine of 1.6 cc.—prior to the use of salt solution, following its use the urine increased to 4.6 cc. The oncometer pressure rose 18 mm. and the general pressure 6 mm.

The following deductions concerning the diuretic value of the different substances employed in these groups of experiments are as follows:

1. In the anuric group, caffeine, theobromine, digitalin and 0.9 per cent salt solution have no effect in reëstablishing the flow of urine. Their failure does not depend upon their inability to raise and maintain a sufficiently high general blood pressure to produce diuresis.

2. The inactivity of these substances is not due to their inability to influence the local renal circulation, for the physiological vascular response of the renal vessels as indicated by the oncometer readings is normal or hyperactive.

3. In the group of experiments classified as practically anuric the same deductions concerning the inefficiency of the diuretics are allowable.

4. In addition to these deductions relative to the effect of the diuretics, this group also shows that the quantity of urine may not only not be increased by the diuretics, but that the output of urine may progressively decrease, even though the general blood pressure readings and oncometer readings show the usual response.

5. In the diuretic group in which the animals show the same physiological response to the diuretics as was shown by the animals in the anuric and practically anuric groups—the sub-

stances effect a diuretic action. Salt solution, 0.9 per cent, shows a more constant diuretic effect, and the increase in the flow of urine from the salt is more pronounced than it is from the other substances.

THE RENAL PATHOLOGY

Five of the animals used in this investgiation were killed either prior to the anesthetic or during its administration. Four of these animals had an early uranium nephritis, were markedly polyuric and had a glycosuria. The fifth animal had a late uranium nephritis, was glycosuric but was not polyuric. The output of urine was reduced below the normal.

In the four early nephritides the vascular pathology of the kidney was much more pronounced than was the epithelial pathology, while in the fifth animal with a late uranium nephritis in which the output of urine had been reduced below the normal, the epithelial pathology predominated. The vascular pathology in the early nephritides consisted primarily of an acute engorgement of the glomerular capillaries. The hyperaemic capillary tufts usually filled the space enclosed by Bowman's membrane and frequently this structure gave the appearance of being distended by the enclosed capillaries. The endothelial nuclei of the capillaries and of the capsular membrane showed no degeneration but were unusually prominent. Within the capilliaries the vacuoles first described by Christian (6) were observed in two of the kidneys.

The intertubular vessels showed the same engorgement with an occasional intertubular exudate containing a few erythrocytes.

With this pronounced vascular reaction on the part of the kidney the epithelial pathology was remarkably slight. The epithelium had not degenerated, it stained well and showed no encroachment upon the lumen of the tubules. (Figs. I and II.)

A comparison of the epithelial changes in these animals, with the epithelial changes in those animals having a complete anuria is as striking as is the difference in the output of urine by the two groups of animals before and after the administration of an anesthetic.

Four of the anuric animals were in an early stage of uranium nephritis, the stage which has just been described as existing in the animals killed before the administration of an anesthetic. In these animals with an early uranium nephritis which were polyuric and glycosuric, and which following the anesthetic became anuric, the vascular pathology was histologically similar to the vascular pathology noted in those animals that had not been subjected to the effect of an anesthetic. The epithelial pathology in these two groups of animals shows, however, a well marked difference. The epithelium in the anuric animals is very greatly swollen and is usually vacuolated. As a result of the swelling the lumen of the tubules has either been very greatly encroached upon or the lumen has become obliterated by an apposition of the opposing faces of the tubular epithelium. The epithelial changes are most pronounced in the convoluted tubules. (Figs. III and IV.)

In the animals grouped as practically anuric, the renal pathology is so nearly similar to the pathology of the kidney in the anuric group that the two allow no histological differentiation.

In the animals grouped as diuretic, the vascular pathology is similar histologically to the vascular pathology which has been described for those animals in the anuric group and also for those animals which were killed prior to the use of the anesthetic. The epithelial pathology, however, differes very much from the epithelial pathology of the anuric group but resembles in its appearance the epithelial reaction seen in those diuretic animals obtained before the use of an anesthetic. (Figs. V and VI.)

SUMMARY

1. Early in a uranium nephritis, usually within the first twenty-four hours, the animals develop a glycosuria and become markedly polyuric.

2. Following an anesthetic, morphine-ether, or Gréhant's, these animals either become completely anuric or the output of urine is greatly reduced.

3. Such animals under the effect of caffeine, theobromine, digitalin and 0.9 per cent salt solution, show a normal response

in the general blood pressure rise and in the vascular response of the kidney.

4. In certain of these animals the flow of urine is increased by these diuretics while in other animals the urine flow is uninfluenced.

5. Histologically the vascular pathology of the kidney is similar in those animals which show a diuretic effect and in those animals which remain anuric.

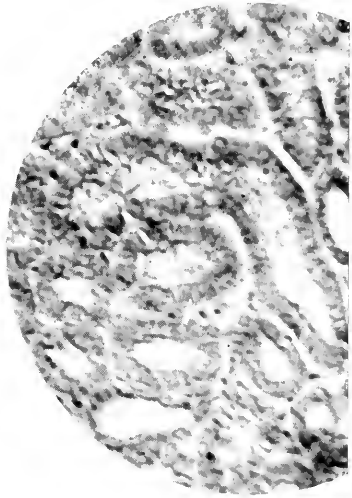
6. Those animals which remain anuric show a physiological vascular response on the part of the kidney vessels similar to the response which is obtained in the diuretic animals. The physiological and the pathological reaction of the kidney vessels in the anuric and in the diuretic animals are, therefore, similar.

7. The two groups of animals differ, however, in the degree of involvement of the epithelial element of the kidney. The anuric animals show an epithelial involvement which is severe and which results anatomically in an encroachment upon, or occlusion of, the lumen of the tubules, while in the diuretic animals the epithelial changes are less marked and are insufficient to produce a mechanical obstruction of the tubular lumen.

8. The pathology of the kidney of those animals with an early uranium nephritis which were examined prior to the use of an anesthetic showed a vascular pathology which in general was similar to the vascular pathology of the anuric, practically anuric and diuretic animals. The tubular epithelium of these animals which were polyuric, showed but slight changes, and in their epithelial reaction the kidneys of these animals were more nearly comparable to the kidneys of the diuretic animals than they were to the kidneys of the anuric animals.

The physiological and anatomical observations which have been made in this investigation indicate that in a uranium nephritis the epithelial changes are more responsible for a reduction in the output of urine or an anuria than are the vascular changes. The way in which these changes influence the output of urine will furnish the basis for a subsequent investigation.

I.



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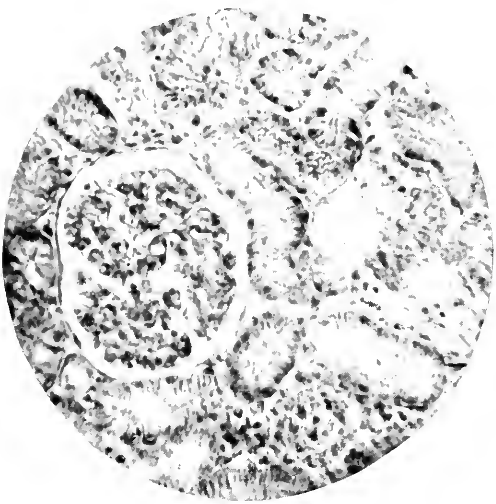

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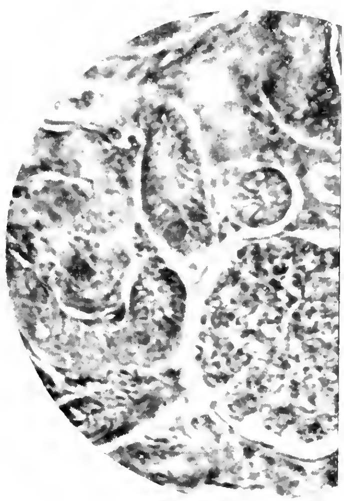
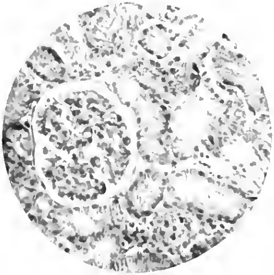


IV.

Plate I

I

II



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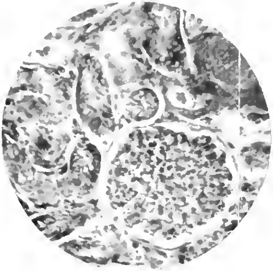

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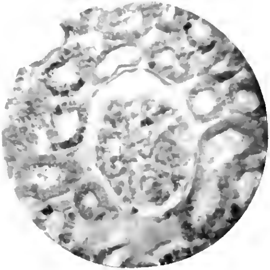

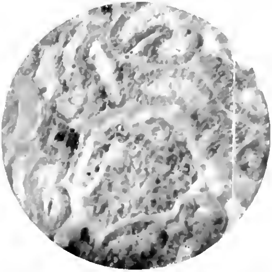

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Figs. I and II

The figures represent the kidneys of a nephritic, glycosuric and polyuric animal before the use of an anesthetic. The glomerular vessels fill and distend the surrounding capsule and show the presence of vacuoles in the capillary walls. The tubular epithelium shows occasion vacuolation, is but slightly swollen and has not encroached upon or occluded the lumen of the tubules. The tubules contain granular detritus. B. and L. obj. 3, oc. 1.

Figs. III and IV

The figures represent the kidneys of two animals which were excessively polyuric before the administration of an anesthetic. Following the anesthetic the animals became anuric. The anuria remained uninfluenced by the diuretics. The vascular pathology is histologically similar to the pathology described in the polyuric animals illustrated by Figs. I and II. The epithelial pathology, however, is strikingly different. The epithelium shows an acute swelling resulting in a nearly complete occlusion of the lumen of the tubules. The acute nature of the swelling of the epithelium is well shown in Fig. III. The anuria was uninfluenced by the diuretics. B. and L. obj. 3, oc. 1.

Figs. V and VI

The figures represent the kidneys of two animals which were responsive to the diuretics. The vascular pathology is similar to that described in the anuric animals. The epithelium shows but slight swelling and no material encroachment upon the lumen of the tubules. B. and L. obj. 3, oc. 1.

Chapel Hill, N. C.

NOTES ON THE BIRDS OF CHAPEL HILL, N. C., WITH PARTICULAR REFERENCE TO THEIR MIGRATIONS.

By Alexander L. Feild.

The material from which these notes are derived was gathered during my four undergraduate years at the University of North Carolina at Chapel Hill,—Sept. 1907 to June 1911. Since the migrating birds occur in the spring and autumn months, I was able to obtain tolerably complete records for the entire time. I made no observations during the three vacation months of June, July and August. A considerable amount of my spare time, however, during the school year was devoted to a study of the birds found in this region. The total number of species positively identified was one hundred and seven. Of this number twenty-nine are known to remain here all through the year and are therefore called permanent residents. Eleven are transient visitors,—birds which during the spring and fall migrations remain here for only a few days or weeks. Twenty are winter residents, which are birds that breed further northward but spend the winter in this locality. Thirty-three occur only in the summer, coming here to breed after their winter residence in the southern United States or the tropics. The remaining fourteen species are of doubtful classification.

I have added five new species to the hitherto catalogued species of Chapel Hill. They are the Red-tailed Hawk (*Buteo borealis borealis*), Red-cockaded Woodpecker (*Dryobates borealis*), Pine Siskin (*Spinus pinus*), Cape May Warbler (*Dendroica tigrina*), Kentucky Warbler (*Oporornis formosus*).

In 1899 Mr. T. G. Pearson published in this Journal (Vol. XVI, Part I) a "Preliminary Catalogue of the Birds of Chapel Hill, N. C., with Brief Notes on Some of the Species." One hundred and thirty-four species are included in this catalogue, one hundred and nineteen of which actually came under his notice. About all of the remaining seventeen species had been recorded previously by Prof. G. F. Atkinson. The latter

published in 1887 in the Raleigh *News and Observer* a "Preliminary List of Birds Collected in the Vicinity of Chapel Hill." Ninety-two species were listed. In an article entitled "A Preliminary Catalogue of the Birds of North Carolina," published in this Journal (Part 2 for 1887), Prof. Atkinson states that he identified about one hundred and twenty species at Chapel Hill, but does not enumerate them. No attempt was made by either of these observers to give any systematic record of bird migration at Chapel Hill.

Following my notes on the one hundred and seven species I met with, I have given a supplementary list of the thirty-three other species that have been previously listed for Chapel Hill, making a total of one hundred and forty. For further information concerning this last list, the reader is referred to Mr. Pearson's article, above mentioned.

The nomenclature used is that of the third edition of the A. O. U. Check List of North American Birds.

1. Green Heron (*Butorides virescens virescens*).

This heron is a summer resident. I did not find it as common as might be expected for this locality. In 1909 the first bird was seen on April 18.

2. Spotted Sandpiper (*Actitis macularia*).

I obtained only one record for this species. This was on April 18, 1909. It is not known to breed here.

3. Killdeer (*Oxyechus vociferus*).

I have seen this bird in December, February, March and April, the latest record being April 13, on which date one individual was seen. They are most abundant in March. No breeding record has been yet secured, although it is probable that they do breed. It is a tolerably common resident in the middle section of the state.

4. Bob-white (*Colinus virginianus virginianus.*)

A common resident throughout the year. I have observed numerous coveys on the campus.

5. Mourning Dove (*Zenaidura macroura carolinensis*).

This bird is common at all times of the year. It is classed

as a game-bird. In 1909 I first heard the Dove's call on February 14; in 1908, on March 8.

6. Turkey Vulture (*Cathartes aura septentrionalis*).

This vulture, commonly called "Turkey Buzzard," may be seen every month of the year. It breeds in this region.

7. Black Vulture (*Catharista urubu*).

A flock of these vultures was seen on January 22, 1909. It may breed in this region, as it has been recorded as a resident in the eastern and middle portions of the state.

8. Sharp-shinned Hawk (*Accipiter velox*).

The only time recorded was on February 9, 1909. There seems to be a scarcity of hawks of all kinds in the region around Chapel Hill.

9. Red-tailed Hawk (*Buteo borealis borealis*).

This hawk was noted only once, April 24, 1909. It has not been recorded by any earlier observer at Chapel Hill.

10. Red-shouldered Hawk (*Buteo lineatus lineatus*).

This is apparently the commonest member of the family in this locality. I have only observed it in December, February, March and April, however.

11. Sparrow Hawk (*Falco sparverius sparverius*).

Next to the Red-shouldered Hawk, the Sparrow Hawk is most often seen. One pair evidently nested in the oaks back of the South Building.

12. Barred Owl (*Strix varia varia*).

In the winter and spring months these birds were heard calling night after night in the forest south of the campus and in Battle's Park. Sometimes several would be heard at once.

13. Screech Owl (*Otus asio asio*).

This little owl is often heard on the campus. I never actually saw but one individual here.

14. Yellow-billed Cuckoo (*Coccyzus americanus americanus*).

This "Rain-Crow" was first seen on May 17 in 1908, and on April 28 in 1911. It is a not uncommon summer resident.

15. Belted Kingfisher (*Ceryle alcyon*).

I have observed this species only in March, April and May, the earliest record being March 25, and the latest May 2. It probably breeds. No record of it has yet been obtained.

16. Hairy Woodpecker (*Dryobates villosus auduboni*).

This bird is not at all uncommon around Chapel Hill. I have seen it in November, December, January, April, and May. The latest spring record was May 27. It breeds here without doubt.

17. Downy Woodpecker (*Dryobates pubescens*).

This is the smallest and most abundant woodpecker at Chapel Hill. It was seen in all months of the year. I met with it most frequently in February. In the middle of this month it starts its loud drumming, which is the mating-call

18. Red-cockaded Woodpecker (*Dryobates borealis*).

The woodpecker has not been recorded for Chapel Hill by earlier observers. I found it a not uncommon bird in Battle's Park and other neighboring woods. This species was seen by me five times in the months of March and April, 1909, the latest being on April 17. The Red-cocaded Woodpecker was usually observed in numbers ranging from two to six.

19. Yellow-bellied Sapsucker (*Sphyrapicus varius varius*).

This common migrant woodpecker occurs here. The average date of its arrival was October 16. The earliest were on Octo-11 in 1907 and 1911. The latest time at which it was seen in the spring was on April 26 in 1911. It was noted in all the intervening months except November, but was most abundant from January 15 to February 15.

20. Pileated Woodpecker (*Phloeotomus pileatus pileatus*).

This large bird was seen on four occasions, the dates being November 28, 1907, January 9, January 22, February 20, 1909. On three of these occasions it was found in the forest several miles south-east of the campus. Only one individual was seen at any one time.

21. Red-headed Woodpecker (*Melanerpes erythrocephalus*).

This handsome bird is a very conspicuous inhabitant of the campus. It is not so abundant in the surrounding region. It seemed most numerous in May. I have no records for December, nor for the first three weeks in January. In 1909 the loud drumming mating-call was first heard on February 5.

22. Red-bellied Woodpecker (*Centurus carolinus*).

One of the anomalies of Chapel Hill ornithology is the abundance of this woodpecker, which is rare in very similar localities. I observed one pair nesting in a hole in an elm in the back-yard of the old Archer place. The time was April. I have also seen this bird during the fall and winter months, except February.

23. Flicker (*Colaptes auratus auratus*).

Next to the Downy the commonest woodpecker. I found it most conspicuous in March. It is a resident species.

24. Whippoorwill (*Antrostomus vociferous vociferous*).

The average date of arrival of this migrant was April 5. The earliest arrival was noted on March 31, 1910. These birds during the spring migrations may be heard calling in large numbers in Battle's Park and the woods south of the campus. Those individuals that remain to breed continue their calling through the first week in May.

25. Nighthawk (*Chordeiles virginianus virginianus*).

This bird breeds at Chapel Hill. I saw one bird perform for several successive evenings the sky-coasting performance, for which the species is famous, over the cemetery and adjoining woods. This was about May 1, 1911. The earliest record I obtained was April 11, in 1908. In 1911 I saw it as late as October 7.

26. Chimney Swift (*Chaetura pelagica*).

My records for the arrival of this well-known summer visitor are as follows: March 31, 1908, April 4, 1909, April 4, 1910, April 5, 1911. In 1908 and 1909 it was last seen on October 10; in 1907, on October 9. In the fall, just before they leave,

these swifts gather in great numbers in the chimneys of the South Building.

27. Ruby-throated Hummingbird (*Archilochus colubris*).

Arrived on April 16 in 1908, and on April 15 in 1909. A common summer resident.

28. Kingbird (*Tyrannus tyrannus*).

I found the Kingbird not very common at Chapel Hill. The earliest spring arrival was on April 26, 1908. In 1907 it was seen as late in the fall as September 3. This flycatcher is not as abundant as in many similar sections of the state.

29. Crested Flycatcher (*Myiarchus crinitus*).

Earliest spring arrival, April 16, 1908 and 1910; average arrival, April 18. Last seen in the fall of 1907 on September 17. This is a very common bird at Chapel Hill, breeding on the campus.

30. Phoebe (*Sayornis phoebe*).

A nest containing three eggs and one young was found by me on April 24, 1909, under the eaves of a mill near Chapel Hill. I have observed the Phoebe during all the nine months of the school year. It was most abundant in February.

31. Wood Pewee (*Myiochanes virens*).

A very common summer resident. Average time of arrival was April 27; earliest arrival was on April 24, 1907. The Wood Pewee was last seen in 1907 on October 14.

32. Acadian Flycatcher (*Empidonax virescens*).

A rather common summer resident. It usually appeared about May 4. Earliest arrival on May 1, 1910.

33. Blue Jay (*Cyanocitta cristata cristata*).

An abundant resident of the campus. It is not so numerous, however, in the surrounding region.

34. Crow (*Corvus brachyrhynchos brachyrhynchos*).

A common permanent resident.

35. Bobolink (*Dolichonyx oryzivorus*).

Small flocks of these migrants were seen April 3-7, 1908,

April 7, 1909, April 5, 1911, on the campus. The males were in song on each occasion.

36. Red-winged Blackbird (*Agelaius phoeniceus phoeniceus*).
This bird is perhaps a rare summer resident. I have it recorded only during November, however. The scarcity of this and other species of similar breeding habits may be due to the absence of much swamp-land or many ponds néar Chapel Hill.

37. Meadowlark (*Sturnella magna magna*).
It may be that these birds breed occasionally here. No record, however, has been obtained. I have observed them from October 22 to April 22. The Meadowlark begins to sing about January 8 and continues until March 30. They are common birds on the campus in the winter and spring months.

38. Orchard Oriole (*Icterus spurius*).
A summer resident on the campus. Is a tolerably common species. Average appearance in spring, April 28; earliest, April 22, 1909.

39. Baltimore Oriole (*Icterus galbula*).
One individual was observed on April 27, 1908, in the arboretum. There is only one other record for this species at Chapel Hill, this being May 2, 1901.

40. Purple Grackle (*Quiscalus quiscula quiscula*).
Only seen on March 5, 1908, and February 12, 1911.

41. Purple Finch (*Carpodacus purpureus purpureus*).
This winter visitor is abundant at Chapel Hill during March and part of April. The latest records I obtained were on April 23 in 1909 and 1911. I did not see it at all in the fall; nor earlier in the winter than February 2. The Purple Finch sings continually from about Februtry 14 until it leaves in the spring.

42. English Sparrow (*Passer domesticus*).
Abundant in town and spreading into the country.

43. Goldfinch (*Astragalinus tristis tristis*).
A common permanent resident, abundant during March and April. Begins to sing about March 19. Found associated largely with the Purple Finch.

44. Pine Siskin (*Spinus pinus*).

This uncommon transient visitor was noted in abundance on the campus from April 23 to May 6, 1911. These are the first recorded at Chapel Hill.

45. Vesper Sparrow (*Pooecetes gramineus gramineus*).

First seen in 1908, on October 30; was seen in December; and on April 3, 1909. A rather uncommon winter visitor.

46. Savannah Sparrow (*Passerculus sandwichensis savanna*).

I only saw this bird in the spring of 1909. It occurs probably as a regular winter bird. I found it common in the arboretum from April 2 to April 23. One individual was heard to sing on April 18.

47. Grasshopper Sparraw (*Ammodramus savannarum australis*).

Observed only on May 30, 1908, and April 10, 1911. It is not known to breed here, but probably does.

48. White-throated Sparrow (*Zonotrichia albicollis*).

An abundant winter visitor. Length of stay: October 14, 1907, to April 11, 1908; October 16, 1908, to May 7, 1909; — — — to May 5, 1910; October 13, 1910, to May 7, 1911. Sings during its entire stay, but most frequently in April.

49. Chipping Sparrow (*Spizella passerina passerina*).

Abundant as a summer resident. Spring arrivals are as follows: March 6, 1908, February 28, 1909, March 9, 1910. It usually leaves about November 10. On December 10, 1907, however, quite a number were seen on the campus.

50. Field Sparrow (*Spizella pusilla pusilla*).

This common permanent resident begins to sing regularly about February 14. One individual was heard as early, however, as January 22.

51. Slate-colored Junco (*Junco hyemalis hyemalis*).

The "Snow-bird" is a very common winter visitor. The average date of arrival was November 10; the earliest, October 25, 1908. In the spring it was seen until April 15 in 1909.

The Junco begins to sing about February 17 and continues until its departure in April.

52. Bachmans Sparrow (*Peucaea aestivalis bachmani*).

A not uncommon bird at Chapel Hill. It arrived in 1908 on April 26, and in 1909 on April 17. I am of the opinion that one pair of these birds usually breeds in the neighborhood of the cemetery.

54. Song Sparrow (*Melospiza melodia melodia*).

My records of the length of stay of this common winter visitor are: October 22, 1907, to March 29, 1908; October 20, 1908, to April 8, 1909; October 21, 1910, to ——. Its song is heard throughout its residence here, but it is most frequently heard during March.

55. Swamp Sparrow (*Melospiza georgiana*).

Observed on only one occasion in the winter (date not known). By no means a common bird in this locality.

56. Fox Sparrow (*Passerella iliaca iliaca*).

This winter visitor arrived in 1907 on November 28. I found it much commoner in the first three months of the year than in November or December. It was last seen in 1909, on March 18. Its song was heard in January, February, and March.

57. Towhee (*Poplio erythrophthalmus erythrophthalmus*).

This bird finds a very congenial winter home in the valleys of Chapel Hill. I found the usual date of arrival to be October 16 (earliest, October 11, 1907). This bird lingers in the spring as late as May 6, which is the average of three years' observations. The last bird seen in 1909 was on May 9. The Towhee begins to sing in the middle of February and continues until about April 6.

58. Cardinal (*Cardinalis cardinalis cardinalis*).

A common resident all the year. Begins to sing in January, but is not in full voice until February 15.

59. Rose-breasted Grosbeak (*Zamelodia ludoviciana*).
One male observed on April 28, 1908, in the village. A rare transient visitor.

60. Blue Grosbeak (*Guiraca caerulea caerulea*).
A not uncommon bird during the spring migration. Arrived on the following days: May 9, 1908, May 9, 1909, May 1, 1910, May 24, 1911. It is without doubt a summer resident here.

61. Indigo Bunting (*Passerina cyanea*).
A very common summer resident, the bird's average arrival for three years being April 24 (earliest record, April 23, 1909, 1911). The Indigo is a persistent singer from the time of its arrival until late summer.

62. Scarlet Tanager (*Piranga erythromelas*).
In 1910 this was a rather common bird on the campus from May 10 to 16. It was not seen at any other time. A rather uncommon transient visitor at Chapel Hill.

63. Summer Tanager (*Piranga rubra rubra*).
This Tanager is the common form at Chapel Hill. It is a resident in the summer. The extreme length of stay was from April 15 (1909) to September 26 (1907). I found it to arrive usually about April 20.

64. Purple Martin (*Progne subis subis*).
In 1908 this swallow, which is rather uncommon at Chapel Hill, arrived on April 22. In 1907 one individual was seen on September 7. I do not know of any that nest here.

65. Barn Swallow (*Hirundo eythrogastra*).
Observed only in the spring of 1908, May 6 to 8, and in the fall of 1909, September 17. On both occasions the birds were migrating in flocks of eight or ten individuals.

66. Rough-winged Swallow (*Stelgidopteryx serripennis*).
The earliest appearance of this bird was on April 10, 1910. It is perhaps a rather uncommon summer resident. In the migration season, however, it is more numerous, being seen regularly every year.

67. Cedar Waxwing (*Bombycilla cedrorum*).

I have seen the Cedar-bird from October 29 to November 8, and from January 4 to May 30. It probably occurs also in December. It is not certain whether it breeds in this locality or not. There are no records of its nesting here. It is very common in the late winter and spring.

68. Loggerhead Shrike (*Lanius ludovicianus ludovicianus*).

My only record for this bird was on October 15, 1907, when one individual was seen in the village. It is a rare winter visitor.

69. Red-eyed Vireo (*Vireosylva olivacea*).

This is the commonest Vireo at Chapel Hill, arriving from the south about April 22 (earliest record, April 18, 1908). It breeds abundantly.

70. Yellow-throated Vireo (*Lanivireo flavifrons*).

A summer resident, almost as abundant as the Red-eyed Vireo, and fully as persistent a songster. It arrives about April 15. (Earliest record, April 8.) In 1907 it was seen in autumn as late as September 21.

71. Blue-headed Vireo (*Lanivireo solitarius solitarius*).

Two birds were observed in the fall of 1907 in the village (date not exactly known).

72. White-eyed Vireo (*Vireo griseus griseus*).

Not as common as would be expected for this locality. A summer resident. Arrived in 1908 on March 29, the average appearance being on April 6.

73. Black and White Warbler (*Mniotilta varia*).

This warbler usually arrived on the first of April (earliest record, March 28, 1909). It breeds here and is tolerably common.

74. Parula Warbler (*Compsothlypis americana americana*).

Usually arrives about April 8. In 1910 the Parula Warbler appeared on April 3, which was my earliest observation. It is very common during the migration season and until May 15. It probably breeds at Chapel Hill. I have an entry for this

species on September 2, 1907, which was as late as I found it in the fall.

75. Cape May Warbler (*Dendroica tigrina*).

In the spring of 1909 this rare bird was tolerably common in the oaks on the campus from April 26 to May 3. These are the first recorded at Chapel Hill, and must be regarded as very rare transient visitors.

76. Yellow Warbler (*Dendroica aestiva aestiva*).

Spring arrivals were: April 20, 1908, April 19, 1909, April 16, 1910, April 18, 1911. Last bird seen in 1907 on September 20. A tolerably common breeding bird.

77. Black-throated Blue Warbler (*Dendroica caerulescens caerulescens*).

Observed only once, on April 25, 1909, in the arboretum.

78. Myrtle Warbler (*Dendroica coronata*).

This warbler is a common winter visitor, reaching Chapel Hill as follows: October 14, 1907, October 25, 1908, October 22, 1909, October 21, 1910. It becomes extremely abundant in March, is less abundant in April, and leaves early in May. (Latest observed, May 15, 1910.)

79. Black-poll Warbler (*Dendroica striata*).

I found this warbler a regular transient visitor, which, during its stay, was almost abundant. It was recorded each year, the earliest arrival being April 29, 1911, the latest May 7, 1908. In 1910 it remained until May 22. Its song was heard during its short residence very often. It was not seen in the fall.

80. Yellow-throated Warbler (*Dendroica dominica dominica*).

An early spring migrant, whose coming was noted as follows: April 7, 1908, March 28, 1909, March 29, 1910, April 7, 1911. In 1907 it was seen until September 14. It breeds and is tolerably common,—very common during the migrations.

81. Pine Warbler (*Dendroica vigorsi*).

A resident all the year and is very common at Chapel Hill. It begins to sing regularly about February 15, although on

warm days in December and January it occasionally bursts into song. It continues to sing until October.

82. Prairie Warbler (*Dendroica discolor*).

A common summer resident in the thickety hill-sides around Chapel Hill. My records for spring arrivals for four years all lie between April 14 and April 18. In 1907 it was noted on September 15.

83. Oven-bird (*Seiurus aurocapillus*).

This bird appeared in the spring during my four years stay from April 10 to April 21. It is without doubt a summer resident; during the migration it is common, becoming only tolerably common later in the year.

84. Louisiana Water-thrush (*Seiurus motacilla*).

This warbler is a resident at Chapel Hill. It appeared in the spring as follows: March 29, 1908, April 15, 1909, March 24, 1910. In 1907 it was seen on September 6.

85. Kentucky Warbler (*Oporornis formosus*).

This bird, which is a rather uncommon summer resident, was first observed in 1909 on May 18. It was noted quite frequently in the woods south of the campus. It has not been hitherto listed as occurring at Chapel Hill.

86. Maryland Yellowthroat (*Geothlypis trichas trichas*).

The first migrants were noted as follows: April 4, 1908, March 29, 1909, April 2, 1910, April 23, 1911. In 1907 it was last seen on October 14, in 1908 on October 19. I found it not very common at Chapel Hill. It breeds here.

87. Yellow-breasted Chat (*Icteria virens virens*).

A very common species, resident in summer. Its appearance was as follows: April 21, 1908, May 9, 1909, May 1, 1910. In 1911 I saw none of these birds, although I looked for them carefully until my departure on May 30.

88. Hooded Warbler (*Wilsonia citrina*).

Observed only on April 24, 1908, in Battle's Park.

89. Redstart (*Setophaga ruticilla*).

Recorded in the spring on April 24, 1908, May 4, 1910: in

the fall, on September 14, 1907, and September 18, 1908. A rather uncommon transient visitor.

90. Pipit (*Anthus rubescens*).

Regularly observed in the winter, being very common at times. Arrived on November 2 in 1908, on October 17 in 1910, and October 22 in 1911. I saw them as late as March 7 (1910). They were often seen near the railroad station and in the athletic field.

91. Mockingbird (*Mimus polyglottos polyglottos*).

This common, permanent resident was heard to sing in every month except September. Its song, however, was heard most in March and April. Often in the spring this peerless songster would sing for hours at night on the campus.

92. Catbird (*Dumetella carolinensis*).

A common summer form, making his appearance in the spring on April 16 to 20. Last seen in 1907 on October 14.

93. Brown Thrasher (*Toxostoma rufum*).

I did not see these birds earlier in the winter than February 14, although it is probable that they stay here in small numbers all through the year. They begin to sing immediately on appearing,—the song being usually mistaken for that of the Mockingbird. They become abundant during March, but fall off in numbers after the wave of migrating birds has passed over.

94. Carolina Wren (*Thryothorus ludovicianus ludovicianus*).

A very common resident all the year. Sings more or less during the whole twelve months.

95. Winter Wren (*Nannus hyemalis hyemalis*).

A rather common winter bird. Arrived in 1907 on October 14. Remained in 1909 until April 15. Have not heard it sing at Chapel Hill.

96. Brown Creeper (*Certhia familiaris americana*).

This bird was seen only in December, February and March. Only in March does it become at all common. In 1909 it was seen until March 23.

97. White-breasted Nuthatch (*Sitta carolinensis carolinensis*).

A very common permanent resident. The prolonged nasal song of this Nuthatch begins to be heard frequently about the middle of January. The song period reaches its maximum in March or April.

98. Brown-headed Nuthatch (*Sitta pusilla.*)

A not uncommon permanent resident. I have seen immature birds of the year.

99. Tufted Titmouse (*Baeolophus bicolor*).

This is a very common resident species.

100. Carolina Chickadee (*Penthestes carolinensis carolinensis*).

Like the Titmouse, a very common permanent resident.

101. Golden-crowned Kinglet (*Regulus satrapa satrapa*).

Arrived in the fall on the following dates: October 15, 1907, October 16, 1908, October 21, 1909, October 12, 1911. This species remains in the pine forests around the village until near the middle of April (April 11, 1908, April 14, 1910).

102. Ruby-crowned Kinglet (*Regulus calendula calendula*).

More of a transient visitor than a winter resident, being rather common in October and March. In 1907 it arrived on October 24, in 1908 on October 25. It arrived for its spring stay on March 18 and was seen until April 21 in 1909. Again, in 1911, this Kinglet was noted until April 23. Its song is often heard during the spring.

103. Blue-gray Gnatcatcher (*Polioptila caerulea caerulea*).

This tiny bird comes usually from the south in the last part of March. The average date of its appearance was March 30 (earliest, March 22, 1908). It is a common summer bird. In 1907 it was seen as late as September 23.

104. Wood Thrush (*Hylocichla mustelina*).

This handsome bird and its sweet song are characteristic of the campus in spring and summer. The extreme length of its stay was from April 8 (1909) to September 23 (1907). The average time of its appearance in spring was April 13.

105. Hermit Thrush (*Hylocichla guttata pallasi*).

This Thrush takes the place of the Wood Thrush when winter approaches. It came on October 15 in 1907, and on November 2 in 1908. In 1909 the Hermit stayed until April 8. It is a common winter bird but does not sing while here.

106. Robin (*Planesticus migratorius*).

A conspicuous resident on the campus, where it breeds. A few remain at Chapel Hill all the year. In February and March , however, the migrating birds reach here and their numbers increase very much. The Robin begins to sing toward the end of January.

107. Bluebird (*Sialis sialis sialis*).

I found this bird common at Chapel Hill at all seasons of the year. In February and March it is abundant on the campus.

The thirty-three species which follow have been previously recorded at Chapel Hill.

1. Holboells Grebe (*Colymbus holboelli*). One specimen taken by Prof. Atkinson in 1877.
2. Pied-billed Grebe (*Podilymbus podiceps*). Recorded by Mr. Pearson.
3. Loon (*Gavia immer*). There are two specimens in the University collection with no date attached.
4. Wood Duck (*Aix sponsa*). Recorded by Mr. Pearson.
5. Bittern (*Botaurus lentiginosus*). Recorded by Prof. Atkinson.
6. Great Blue Heron (*Ardea herodias herodias*). Catalogued by Mr. Pearson.
7. Egret (*Herodias egretta*). One specimen shot by Mr. Dedrick in 1894.
8. Sora (*Porzana carolina*). One taken in November, 1887, now in the University collection.
9. Coot (*Fulica americana*). One recorded by Prof. Atkinson on April 8, 1887.
10. Woodcock (*Philohela minor*). Catalogued by Mr. Pearson.

11. Wilsons Snipe (*Gallinago delicata*). Catalogued by Mr. Pearson.
12. Solitary Sandpiper (*Helodramas solitarius solitarius*). Listed by Prof. Atkinson.
13. Wild Turkey (*Meleagris gallopavo silvestris*). Recorded by Mr. Pearson.
14. Marsh Hawk (*Circus hudsonius*). Catalogued by Mr. Pearson, one specimen being secured on April 5, 1899.
15. Coopers Hawk (*Accipiter cooperi*). Catalogued by Mr. Pearson.
16. Broad-winged Hawk (*Buteo platypterus*). One specimen recorded by Mr. Pearson.
17. Bald Eagle (*Haliaeetus leucocephalus leucocephalus*). One observed by Mr. Pearson.
18. Great Horned Owl (*Bubo virginianus virginianus*). Catalogued by Mr. Pearson.
19. Chuck-wills-widow (*Antrostomus carolinensis*). One individual heard by Mr. Pearson on May 20, 1899.
20. Horned Lark (*Otocoris alpestris alpestris*). Recorded by Mr. Pearson on November 23, 1898.
21. Rusty Blackbird (*Euphagus carolinus*). Catalogued by Mr. Pearson. Two killed by Mr. Ivy Lewis on February 3, 1899.
22. Tree Sparrow (*Spizella monticola monticola*). Listed by Prof. Atkinson.
23. Tree Swallow (*Iridoprocne bicolor*). Catalogued by Mr. Pearson.
24. Worm-eating Warbler (*Helmitheros vermivorus*). Catalogued by Prof. Atkinson.
25. Magnolia Warbler (*Dendroica magnolia*). Two specimens taken by Mr. Pearson in September, 1897.
26. Chestnut-sided Warbler (*Dendroica pensylvanica*). One bird taken by Mr. Pearson on September 21, 1897.
27. Bay-breasted Warbler (*Dendroica castanea*). One taken by Mr. Pearson on October 2, another on October 8, 1897.

28. Blackburnian Warbler (*Dendroica fusca*). One bird killed by Mr. Pearson on October 16, 1897.
29. Black-throated Green Warbler (*Dendroica virens*). Catalogued by Mr. Pearson.
30. Water thrush (*Seiurus noveboracensis noveboracensis*). Seen by Mr. Pearson.
31. House Wren (*Troglodytes aedon aedon*). Listed by Prof. Atkinson.
32. Veery (*Hylocichla fuscescens fuscescens*). Listed by Prof. Atkinson.
33. Olive-backed Thrush (*Hylocichla ustulata swainsoni*). One specimen secured by Mr. Pearson on September 26, another on October 9, 1897.

There are a number of species which probably occur at Chapel Hill but have not been observed up to this time. Some of these are Little Blue Heron (*Florida caerulea*), King Rail (*Rallus elegans*), Black-billed Cuckoo (*Coccyzus erythrophthalmus*), Cowbird (*Molothrus ater ater*), Bank Swallow (*Riparia riparia*), and Red-breasted Nuthatch (*Sitta canadensis*).

Raleigh, N. C.

THE SEEDLINGS OF THE LIVE OAK AND WHITE OAK.

By W. C. Coker.

In the Plant World for May, 1911, Mr. Isaac Louis has an interesting article on the germination of the acorn of *Quercus virginiana.* So far as I know his figures of the live oak seedling are the first published, but he overlooks the previous publication of most of the facts by others.

The appearance of a tuberous swelling on the root of the seedling of this species was first discovered by Mr. William St. J. Mazyck, of Georgetown, South Carolina, who, by letters and specimens, called the attention of several botanists to the fact. Among those he communicated with were Dr. George Engelmann, of St. Louis, and Mr. Thomas Meehan, of Germantown, Pennsylvania. In the Transactions of the Academy of Science of St. Louis, Vol. IV, 1880, Dr. Engelmann has an article on "The Acorns and their Germination," which opens as follows:

"The structure of the acorns and the germination of the oaks seem to be so well known, that I did not pay much further attention to it until my interest was excited by the information that the germinating live-oak developed little tubers, well known to the negro children, and greedily eaten by them. The notes and specimens obtained from my South Carolina correspondents, Messrs. H. W. Ravenel, W. St. J. Mazyck (who was the first to notice this), and Dr. J. H. Mellichamp, enabled me to examine the germinating live-oak and to compare it with other oaks in this condition."

After describing the usual process of sprouting in oaks he says:

"The process in *Q. virens*[1] is essentially the same; it differs somewhat in that the connate stalk of the cotyledons remains more slender, but elongates more, mostly to the extent of one inch or even more; the cuticle and the upper part of the root

[1] *Quercus virens Ait* is another name for the live oak, *Quercus virginiana Mill.*

swells up at once, while the developing plumule forces its way up through a slit in the base of the stalk. It seems that the danger of losing connection with the storehouse of the cotyledonous mass through the long and slender passage of the stalk, necessitates the transfer of the food-matter to a nearer and safer place of deposit. But why, it may be asked, is the connection so much longer and more slender than in the other oaks? At all events it suffices, so long as it is fresh and unimpaired, to carry over in a very short time the starchy and sweet contents from the cotyledons to the tuber; and before the ascending axis is an inch high and bears as yet only a few minute bracts, the tuber is already forming and it soon reaches the size of the cotyledons themselves; it is, however, longer and more slender, of a fusiform shape, about three or four lines thick and one or two inches long, attenuated below into the long tap-root."

"The whole process is similar to the germination of the cucurbitaceous Magarrhiza of California, so beautifully illustrated by Gray in his structural Botany; with this difference, that the cotyledons in that plant are raised above the ground,[2] while in ours they remain hypogaeous, and that the stalk is even longer, and is, together with the cotyledons, readily separable into its two component parts. In both plants a tuber forms at once by the transfer of the food-matter from the cotyledons to the radical; in the herbaceous Megarrhiza the tuber becomes a permanent organ of immense size, while in the arboreous live-oak it is finally merged into the root."

It may be of interest, also, to give two of Dr. Engelmann's letters to Mr. Mazyck (not before published), in which this subject is referred to. On March 10th, 1880, he writes:

"WM. ST. J. MAZYCK, ESQ.,

Dear Sir:—You will find from a little paper which I published in the St. Louis Academy Transactions, and which I will send in a few days, that I studied not only the germination but also the structure of the acorn itself and find in it an interesting character.

[2] "But only exceptionally" is the foot note at this point by the editors of Dr. Engelmann's collected works.

I forget how far I entered into this matter in my last, of Feb. 21st, but if I should repeat myself here you will forgive me.

You know how a bean and a pea germinate: both with thick fleshy cotyledons which do not expand into leaves, as many plants do. The difference between them is that the cotyledons of the pea remain under ground, while the bean's are elevated on the stem above it.

Well, the acorns behave like the pea, but the cotyledons remain enclosed in the shell while their stems or stalks, or petioles come out and enclose between them the stem which grows up. If you pick up any seedling oak, you will find it so, and removing the shell, you can separate the cotyledons from one another and examine the whole arrangement.

In most white-oaks the stems are longer, in the black-oaks shorter, and that is already seen in the acorn itself. In the live-oak it is longest already within the acorn, and in all of them it lengthens in germination more or less.

The question with me now is, how soon does the tuber in the live-oak swell and how long does it last.

I suppose that it begins to swell immediately when formed, attaining its full size, perhaps, in the fall, or it may grow for several years. I have a young live-oak, apparently three years old, with the biggest tuber I have ever seen.

And I suspect that the tuber is hardly absorbed but gradually merged into the root. . . . . "

On April 7th, 1880, he writes again:

"WM. ST. J. MAZYCK, ESQ.,

Dear Sir:—Enclosed please find the results of my studying of the germination of acorns and of their structure.

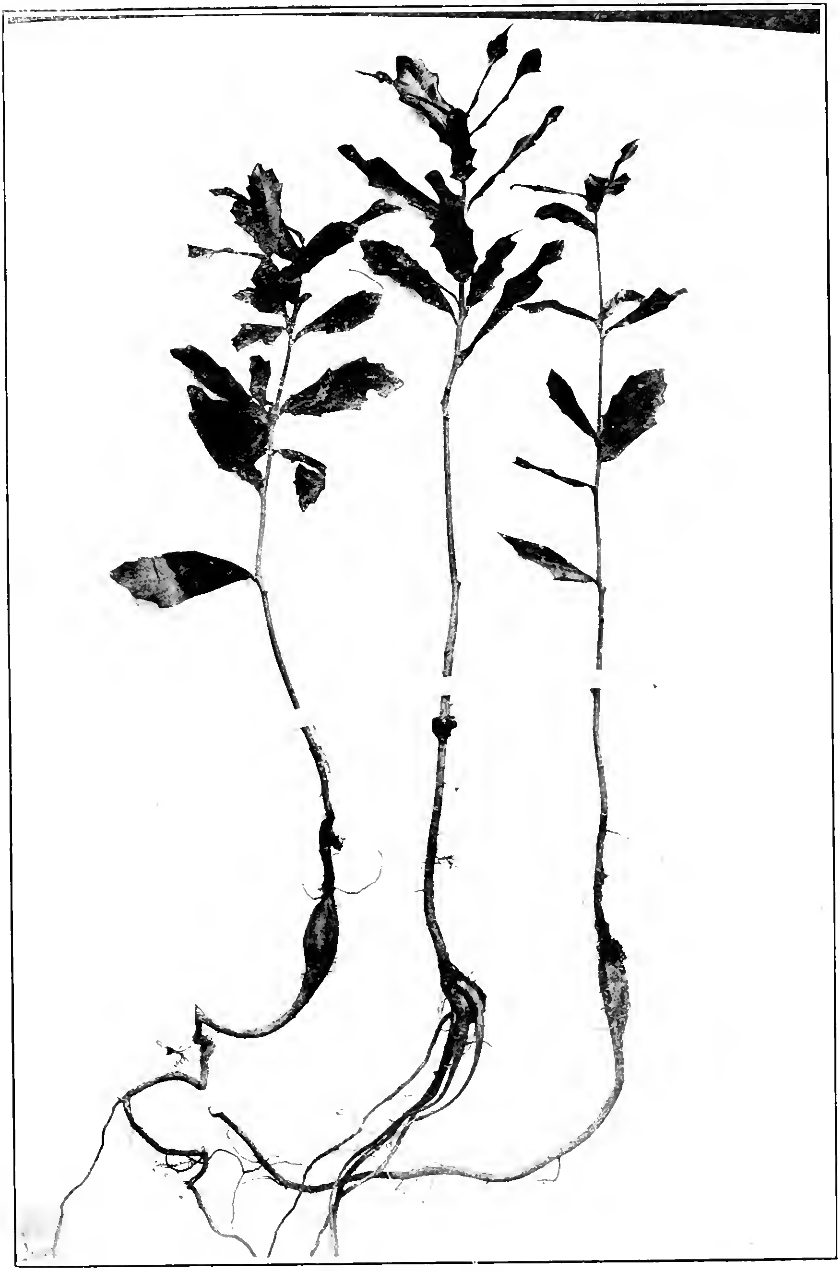
In regard to the germinating *Q. virens* we ought to know yet:

1st. How soon the tuber forms: from your many accounts I judge that it forms before any leaves are developed.

2nd. When the cotyledons are exhausted and what relation their increase bears to the increase of the tuber.

How long the tuber continues to grow larger, and at what age of the plant it becomes merged in the root or base of the trunk.

I have a specimen about four or five years old, in which the tuber is the largest of any I have ever seen, but, of course, hard and ligneous.



Seedlings of Live Oak.

By examining other acorns but those of the live-oak you will be able to find out what by my description is meant."

Mr. Thomas Meehan, a well known horticulturist of that time, also gave an account of the live-oak seedling, before the Philadelphia Academy of Natural Science. In the Society's Transactions for the year 1880, pages 128 and 129, we find the following:

"Mr. Thomas Meehan referred to some interesting facts in the germination of *Quercus virens,* as brought to his attention by W. St. J. Mazyck, of Georgetown, S. C. It was generally known that in this species the cotyledons did not divide into two lobes as usual in acorns, but seemed to be one solid mass, without any trace of division. In germination, however, two petioles were developed as in other acorns, but instead of these being very short, indeed nearly sessile, as in the ordinary white-oak, they were produced apparently in the much advanced specimen sent by Mr. Mazyck to one and one-half inches in length before the plumule and hypocotyledenary portions of the embryo commenced their growth. In respect to the latter, a small ovate striate tuber, apparently, as one might judge from the shrivelled specimens on hand, nearly one-fourth the size of the acorn, was formed, and from the tuber the radicle proceeded, and, afterwards the plumule on its upward growth. . . . .

"Mr. Edward Potts, at the request of Mr. Meehan, had made sections of both the acorns and the spindle-shaped radicle, with the results of finding the cell structure of the latter an almost exact counterpart of that of the nut: *i. e.,* sub-spherical cells of uniform size, gorged with starch grains. So similar were they that it would be nearly impossible for an observer to say which he was examining but for the cortical tissue surrounding the root. It seemed that the food supply of the young plant had been thus withdrawn from a portion exposed to hot sun and drying winds to be protected by the earth and in the direct line of growth. No line of specialized cells could be discovered in the sections of the nut, indicating the possibility of separation as in other species into two cotyledons; so that to all intents and purposes it might be called monocotyledonous."

In an unpublished letter, of February 6, 1880, to Mr. Mazyck, Mr. Meehan says:

"I am very much obliged by your letter and samples of live-oak. I knew before that this species is monocotyledonous, and that the development of the radicle and ultimately plumule, is as you describe. Other oaks have somewhat the same character, but not the same degree. But I did not know of the swelling of the radicle. I shall call the attention of the Academy of Science to this interesting fact at its next meeting. . . . "

In a later letter (February 29, 1880) we find the following:

" . . . The acorn matter was very interesting to the members. Some examinations of other species have since been made, and it is found that so far as the lengthening of the petioles of the cotyledon is concerned, many have it to a greater or less degree, and the discovery of yours will be of very great value in the determination of the species. Drawings will be made and published of many species, but I made a formal address before the Academy at its meeting on last Tuesday evening, so that the discovery may be placed on record to your credit. It may be some months before this is published officially by the Academy, but as soon as it is I will send you a copy.

One of the tubers was examined microscopically by Mr. Potts of the Microscopical Section, and found to contain starch granules of precisely the same character as those of the original cotyledon.

Thanking you for your interesting facts, I am,

Very truly yours,

THOMAS MEEHAN,
2nd Vice-President Academy of Natural Science of Philadelphia

In my article on Dr. Mellichamp (Journal of the Elisha Mitchell Scientific Society, May, 1911), I published, on page 50, a letter of Dr. Mellichamp's which is concerned in part with this matter. He says:

"If I could only have received these queries when I was last in Bluffton I could have answered them accurately, but now I cannot do so, and I do not wish to trust to my memory of some years back when I not only planted the live-oak acorns, but

examined the young roots after a year or two and even reported the results to my dear friend Engelmann, of St. Louis, who had been put on the track by Wm. St. J. Mazyck, who spent a pleasant morning with me at the mill, when I was last at Charleston. . . . "

As Mr. Lewis did not publish any late stages of the seedlings, it may be of interest to show the accompanying photograph (Plate II), of three seedlings about fifteen months old taken by me last fall. The plant in the center shows the interesting peculiarity of having a cluster of small tubers instead of a single large one.

In one of the above quotations from Dr. Engelmann he asks why the petiole of the cotyledons should be so much longer in the live-oak than in the other oaks. The answer is probably to be found, as suggested in the Proceedings of the Philadelphia Academy, and as expressed by Mr. Lewis, in the "advantages to the plant in establishing itself in the semi-arid situations in which it is often found." In the South-Eastern States at least the live-oak is partial to very sandy soils near the shore, and such soils are necessarily subject to rapid surface desiccation. Retention of the food stuff in the cotyledons for a long time would be dangerous, as the cotyledons might be prematurely dried and killed.

In regard to the association of fused cotyledons and the tuberous habit, there is a very interesting analogy, that does not seem to have been noticed before, between the live-oak and a number of other dicotyledons. In the development of her theory of the origin of monocotyledons, Miss Ethel Sargant has clearly brought out the existence of a close correlation between the geophilous[1] habit and a fusion of the cotyledons. In the Botanical Gazette, for May, 1904, Miss Sargant[2] has an article on "The Evolution of the Monocotyledons," in which she writes as follows in regard to dicots with fused cotyledons:

---

[1] The live oak does not, technically, come under Prof. Areschong's definition of a geophilous plant, as it does not periodically lose its above-ground parts; but it is, nevertheless, a geophilous plant in its youth.

[2] See, also, Miss Sargant's more recent article in *Annals of Botany*, Vol. XXII, p. 121, 1908, where the literature is given.

"They belong to eight genera which are systematically scattered, for they represent six families, *Ranunclaceae, Fumariacea, Umbelliferae, Primulacae, Lentibularieae* [sic], *Nyctagineae.* Clearly these species cannot have inherited the peculiar form of their seedling from a common ancestor. It must be due to similar external conditions affecting certain species of very different descent in the same way.

"One feature is common to all of the pseudo-monocotyledons in my list—they all possess some underground member which is thickened into a tuber. In *Ranunculus Ficaria* one of the earlier cauline roots became tuberous; in the other species the hypocotyl is more or less thickened.

"Moreover, the most complete list I can make of dicotyledons with their cotyledons partially united for some distance from the base upwards included twenty genera. It contains but one genus—*Rhizophora*—in which the hypocotyl is not very much shortened, if not actually thickened. In the great majority the hypocotyl becomes a conspicuous tuber. The seeds of the single exception germinate under peculiar conditions, which would account for most any amount of modification in the structure of the seedling. . . . . . "

And a little further on, she says:

"The formation of assimilating organs in the seedling of a geophilous plant is, however, very greatly limited by the shortness of the growing season and the necessary formation of subterranean organs. Here lies the explanation we are seeking: the reduction of the cotyledons and the formation of a tuber are both adaptations to the geophilous habit. . . . . . "

Is it not remarkable that these observations should apply so exactly to *Quercus virginiana*, the oak which shows the strongest tendency[1] to the geophilous habit?

In the Botanical Gazette, Vol. XXXVII, p. 62, I published a drawing of an acorn *Quercus Prinus L.* from which three healthy young plants were sprouting. Most of the acorns from the same tree were also multiseeded. There is in Chapel Hill,

[1] All oaks show a slight tendency towards the geophilous habit in the concentration of the early growth in the root, and Englemann mentions the occasional fusion of the cotyledons in *Quercus pungens*, a shrub of dry regions in the West.

Seedlings of White Oak.

N. C., a magnificent tree of *Quercus alba L.* that shows the same peculiarity. Through a number of years I have watched this tree and there are always a large proportion of its acorns that contain two or three young plants. A further point of interest is that the seedlings from these acorns show a strong tendency to put out branches from the axils of the cotyledons. Three of these young plants, all from multiseeded acorns, are shown in plate III. Each has an additional shoot springing from one cotyledonary bud. Usually only one of the two auxillary buds grows, but there is frequently an effort to put out both buds, the second rarely reaching more than a centimeter in length. As a result of this combination of peculiarities it might happen that if there were three embryos and each produced a bud from its cotyledon, as many as nine shoots would appear above the ground from a single acorn. It is probable, however, that this never occurs, and the largest number I have ever seen is five, consisting of three primary shoots and a bud from one cotyledon of two of them.

There is evidently a correlation between this tendency to multiseeded acorns and the formation of buds at the cotyledons, both being the result of an unusual tendency towards fecundity or proliferation that is inherent in the nature of this tree.

Among the three seedlings shown in the photograph, the one to the right exhibits a still further peculiarity. Several latteral roots have appeared on the hipicotyl—a most unusual occurrence for the oak. These roots may be seen coming from the stem as far up as three-quarters of a centimeter above the attachment of the cotyledons.

Chapel Hill, N. C.

AN EXPERIMENTAL PROOF OF INVERTED RETINAL IMAGES*

By A. H. Patterson

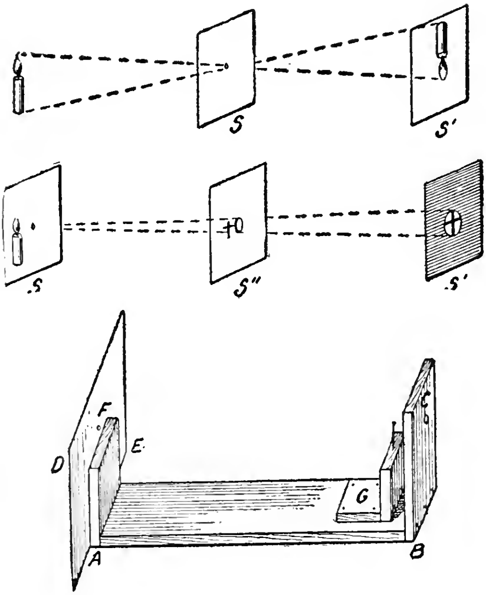
It is usually somewhat mystifying to be told that all upright objects, such as trees, men walking, etc., form inverted or upside-down images on the retina of the eye. However, it is easy to construct a simple bit of apparatus which will prove the point in question. But first we must understand clearly one or two principles of the action of light rays.

Take a sheet of cardboard *S* and pierce in it a small hole about one-tenth of an inch in diameter. In front of it place a lighted candle, and behind it a cardboard screen *S'*. On this latter screen will be seen an inverted image of the candle—a so-called "pin-hole image." Now place the candle quite close to the screen *S* and let its light shine through the small hole upon the screen *S'*. Then take a third cardboard screen *S''*, from the middle of which is cut a hole 1 inch in diameter, and place it between the two screens *S* and *S'*. The divergent pencil of rays coming through the hole in *S* and the inch hole in *S''* will illuminate a circular area on the screen *S'* slightly more than an inch in diameter. Take some object, say a small cross, and hold it upright before the hole in *S''*. It will cast a shadow in the circular lighted area on screen *S'*, and this shadow will be upright. There is no reason why it should be otherwise. If, now, a double convex lens is held behind the hole in screen *S''*, the size of the lighted area and the cruciform shadow on *S'* will be altered, but the shadow will still be upright.

Now for our experiment. Construct of thin pieces of wood a frame like that shown in the drawing. The distance *AB* is about 7 inches; the hole *C* is about one-tenth of an inch in diameter, and *DE* is piece of white letter paper about 4 inches square, pasted over the wooden upright at the left. At *F* a tiny hole is pierced through the paper with an

*Reprinted from the Scientific American, June 3, 1911.

ordinary pin. Now stick a pin upright in the block *G* and adjust the position of the block so that the head of the pin is exactly in line between the holes *C* and *F*, and three-fourths of an inch from the hole *C*. Fix the block *G* in this position. This completes our apparatus. Placing the eye close to the hole *C* and looking through hole *F* at the sky, we see a lighted



circular area with the shadow of the pinhead in its center, but *this shadow is inverted.* We are ready to declare that the pin is upside down, for it certainly looks so. When we reflect a moment, however, we see that we have now exactly the same arrangement as in the middle diagram. The hole *F* represents the hole in the screen *S*, the pinhead represents the cross, the pupil of the eye represents the hole in screen *S''*, and the retina of the eye takes the place of screen *S'* and receives the upright shadow of the pinhead upon it. The crystalline lens of the eye acts precisely like the lens in Fig. 2, altering the size of the retinal shadow, but not its upright

position. This upright shadow on the retina, however, makes us think that the object throwing it is inverted, for the shadow certainly "looks" inverted to us. But we know that the object throwing the shadow is upright, and it follows in consequence that the retinal images of upright objects are inverted. In using this apparatus the eye must not be focussed on the pin, or the hole *F*, but on something distant, like the clouds or the twigs of trees between the observer and the sky.

Chapel Hill, N. C.

VOL. XXVIII AUGUST, 1912 No. 2

JOURNAL

OF THE

Elisha Mitchell Scientific Society

ISSUED QUARTERLY

CHAPEL HILL, N. C., U. S. A.

TO BE ENTERED AT THE POSTOFFICE AS SECOND-CLASS MATTER

Elisha Mitchell Scientific Society

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ARCHIBALD HENDERSON, Vice-President
R. A. HALL, Recording Sec. F. P. VENABLE, Perm. Sec.

EDITORS OF THE JOURNAL:
W. C. COKER
J. M. BELL, A. H. PATTERSON

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JOURNAL

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Elisha Mitchell Scientific Society

VOLUME XXVIII AUGUST, 1912 No. 2

PROCEEDINGS OF THE ELEVENTH ANNUAL MEETING OF THE NORTH CAROLINA ACADEMY OF SCIENCE.

HELD AT THE UNIVERSITY OF NORTH CAROLINA, CHAPEL HILL, N. C., FRIDAY AND SATURDAY, APRIL 26-27, 1912.

The Executive Committee met at 2.30 p. m., Friday, April 26, there being present Pres. H. V. Wilson and Sec'y E. W. Gudger *ex officio,* and Prof. A. H. Patterson, Dr. J. J. Wolfe, and Mr. F. Sherman, Jr. The Secretary reported that during 1911 ten members had withdrawn or been dropped for non-payment of dues, six new members had been added, and one old member reinstated on payment of back dues, making a total membership of 85 on Jan. 1, 1912. The Secretary also read his financial statement.

The following new members were then unanimously elected:

(1) E. E. Balcomb, professor of Agriculture, State Normal College.

(2) T. A. Bendrat, Instructor in Geology, University of North Carolina.

(3) W. H. Booker, Assistant Secretary State Board of Health.

(4) Dr. H. R. Fulton, Professor of Botany and Plant Pathology, Agricultural and Mechanical College.

(5) D. R. A. Hall, Associate Professor of Chemistry, University of North Carolina.

At 3 p. m. President Wilson Called the Academy to order and appointed the following committees:

Nominating — Collier Cobb, Z. P. Metcalf, and C. A. Shore.
Auditing — J. J. Wolfe, A. H. Patterson, and C. S. Brimley.
Resolutions — F. Sherman, Jr., E. W. Gudger, and W. A. Withers.

The reading of papers was then begun and continued until adjournment at 5:30 p. m., at which time eleven had been finished.

At 8 p. m. the Academy reassembled in Chemistry Hall and was cordially welcomed to Chapel Hill by President F. P. Venable, of the University of North Carolina. President Wilson, of the Academy, after responding to the address of welcome, then delivered the Presidential Address: "Zoology in America Before the Present Period." The hall then being darkened, Prof. A. H. Patterson gave a beautiful demonstration of luminous electric waves. Next, by special invitation, Dr. Thomas W. Pritchard gave his paper on "Wood Distillation." This being a new and important industry for our state was of much general interest to the members of the North Carolina Section of the American Chemical Society. At the same hour, Dr. W. S. Rankin, Secretary State Board of Health, delivered a lecture on "Hygiene and Sanitation" before the student body of the University, in Gerrard Hall.

The Academy then adjourned to attend the smoker given by the local members at the hospitable home of Dr. Isaac H. Manning, while the ladies in attendance were entertained at a reception by Mrs. Dr. Lawson.

The Academy reconvened at 9:10 a. m., Saturday morning, in annual business meeting. The minutes of the last meeting were read and approved.

The Nominating Committee reported for officers for 1912-13: President, Mr. C. S. Brimley, Naturalist, Raleigh; Vice-President, Prof. John F. Lanneau, Professor of Astronomy, Wake Forest College; Secretary-Treasurer, Dr. E. W. Gudger, Professor of Biology and Geology, State Normal College. Additional members of the Executive Committee: Prof. Julian Blanchard, Professor of Engineering, Trinity College, Durham; Mr. S. C. Clapp, Orchard and Nursery Inspector, State

Department of Agriculture, Raleigh; Dr. John A. Ferrell, Secretary for Hookworm, State Board of Health, Raleigh. The nominations were adopted unanimously.

The Auditing Committee reported the Treasurer's statement correct, and it was ordered printed in the minutes.

RECEIPTS

Balance last audit	$183.58
Dues paid 1912	99.00
Interest Savings Bank Deposit	5.39
Total	$287.97
Expenses	94.97
Balance	$193.00

EXPENDITURES

Printing	$ 5.50
Proceedings	75.00
Type Writing	2.35
Stamped Envelopes	12.12
	$ 94.97

RESOURCES

Savings Bank Balance	$138.68
Checking Bank Balance	54.32
Total	$193.00
Dues unpaid, 1912	25.00
Stamped Envelopes on hand	7.50
	$225.50
Less Outstanding Debts	82.00
Estimated Balance	$143.50

OUTSTANDING DEBTS

Proceedings, 1911-12	$ 75.00
Miscellaneous (about)	7.00
	$ 82.00

The Committee on Resolutions moved: That we hereby express our sincere thanks to the University for granting us the use of appropriate rooms for our meetings; to the Faculty and ladies for their kindly attentions; and to Dr. Isaac Manning for the pleasant smoker of last evening. And this was carried unanimously.

At the suggestion of Professor Edwards, and on motion of Professor Patterson, the President appointed a committee to work up and bring before the Academy, at its next annual meeting, a report on ventilation of school houses, churches, courthouses, theatres, and other public buildings in our state. After consideration by the Academy, it is hoped that we may be able to make recommendations to the State Legislature with regard to laws on ventilation. The committee consists of Prof. C. W. Edwards, Professor of Physics, Trinity College; Prof. A. H. Patterson, Professor of Physics, University of North Carolina; and Dr. C. A. Shore, Director State Laboratory of Hygiene.

At 9:30, by special arrangement between the Secretaries of the two bodies, there was held a joint meeting of the Academy and the North Carolina Section of the American Chemical Society, at which Dr. J. E. Mills gave his "Report on Molecular Attraction and Gravitation," and the chemical papers on the program of the Academy were read. The Chemists then adjourned to hold their stated meeting, and the reading of papers was continued in the Academy until adjournment for luncheon at 1:30, at which time twenty-five papers had been read. On reconvening after luncheon the consideration of papers was completed, and adjournment had at 3:20 p. m.

The following members were in attendance: Bendrat, T. A.; Blanchard, Julian; Booker, W. H.; Brimley, C. S.; Cain, William; Clapp, S. C.; Cobb, Collier; Daggett, P. H.; Edwards, C. W.; Ferrell, J. W.; Gudger, E. W.; Hall, R. A.; Herty, C. H.; Hutt, W. N.; Ives, J. D.; Lay, G. W.; Lockhart, L. B.; Metcalf, Z. P.; Metcalf, Mrs. Z. P.; Mills, J. E.; Patterson, A. H.; Rankin, W. S.; Sherman, Franklin, Jr.; Shore, C. A.; Tillman, Miss O. I.; Venable, F. P.; Wheeler,

A. S.; Wilson, G. W.; Wilson, H. V.; Withers, W. A.; Wolfe, J. J.—31 out of a total membership of 90.

In addition to the Presidential Address, and the demonstration of electric waves, the papers on the Academy's program numbered twenty-nine. Of these four were read by title, one was reported on by President Wilson in the absence of the member, and the others were all read in order as shown on the program. Two things characterized the meeting: First, the number of papers dealing with hygiene, sanitation, and public health; and second, the discussions which followed the presentation of nearly every paper on the program.

In addition to the Presidential Address and the demonstration of electric waves, the following papers were presented:

Notes on the Distribution of the More Common Bivalves of Beaufort, N. C., Henry D. Aller.
[Published in full in this issue.]

The Relation of Vital Statistics to Public Health Work, Warren H. Booker.

Further Notes on the Yellow Fever Mosquito at Raleigh, C. S. Brimley.

Although this species was common in my vicinity in 1910, it was ten times more abundant last year (1911).

In the early part of the season it appeared to be mostly confined to the southern half of the city, and mainly to the eastern half of that; later on, it spread practically all over Raleigh, having reached the city limits on Hillsboro street in the west, and nearly as far on Glenwood avenue in the northwest. At both these places, however, it only occurred in small numbers. Over the major portion, however, of Raleigh it was very abundant and annoying from August to October inclusive, while at my house it was noted from late July to mid-November.

Unlike other mosquitoes, it bites in the daytime, even during the period of brightest sunshine, and appeared to show a decided inclination to bite people on the ankles, so that the wearers of

low-cut shoes suffered more than other people. Only the females were observed to bite, but the males were also noted to come around a sleeping child when protected with mosquito netting, and to perch on the netting as if they also wished to bite. None of this sex, however, was found with the bodies distended with blood. The sexes were present in about equal numbers.

Occasional specimens of this species have been taken in the past, and in 1910 they were common, increasing vastly in numbers in 1911. Now, what was the cause of this? I surmise that the series of mild winters preceding 1911 was one cause why this southern species got such a foothold. Another reason, I believe, was that owing to the drought, the rain-water barrels used by negroes stayed undisturbed for several weeks with just enough water in them to keep them from falling apart, and as, of course, no water was drawn from them and none ran in, the mosquitoes had an excellent opportunity to breed undisturbed, and it takes a very little water to supply breeding places for thousands of these little pests.

Some Records of Incipient Fern Growth in Carboniferous Time, Collier Cobb.

Race Preservation, Geo. W. Lay.

Notes on the Larvae of the Marbled Salamander, E. W. Gudger.

Larvae 1½ to 2½ inches long, with external gills, have been taken in brooks in the college park for several years past. This spring some thirty or forty were taken in a muddy pool in the same park. When caught these were nearly colorless, but when exposed to the light in aquaria set before windows in the laboratory they very quickly became pigmented. These were first thought to be the young of the common salamander, which had retained their gills over winter, but discussion of the paper elicited the interesting information from Mr. C. S. Brimley that the Marbled Salamander lays its eggs in the fall, these are hatched and the larvae retain their gills over winter, losing them in the late spring. Some kept by the writer for a month now show only stumps of these structures.

The Seedling of the Live Oak, W. C. Coker.
[Published in full in this Journal for May, 1912.]

Notes on Mutation, W. N. Hutt.

The Effect of Temperature on the Contact Resistance of Carbon, P. H. Daggett.

The Gloomy Scale, an Important Enemy of Shade Maples in North Carolina, Z. P. Metcalf.
[Published in full in this issue.]

The Dispensary as a Factor in the Prevention and Cure of Hookworm Disease, John W. Ferrell.
[Published in full in this issue.]

Two Parasitic Hymenomycetes, Guy West Wilson.

Attention is called to the attacks on apples in the Piedmont section of the state by *Septobasidium pedicellatum* (Schw.) Pat. which also occurs over a considerable area of the Southern states on various hosts. *Fomes roseus* (Albert & Schw.) Cooke, is also noted as causing a disease of the red cedar, locally very destructive in Eastern North Carolina.

The Toxicity of Cotton Seed Meal, W. A. Withers and B. J. Ray, with the co-operation of R. S. Curtis and G. A. Roberts.

The Walden Inversion, Alvin S. Wheeler.

Note on the Fundamental Basis of Dynamics, William Cain.
[Published in full in this issue.]

Discovery of some new petroglyphs Near Caicara on the Orinoco, T. A. Bendrat.

In the winter of 1908 and '09, while surveying the region about Caicara, Venezuela, the writer discovered some new petroglyphs which belong, geographically and genetically, to the

same large group of stone-carvings found scattered over a wide area which is bounded by the Orinoco, the Atabapo, the Rio Negro, and the Cassiquiare. While Alexander von Humboldt mentions only two petroglyphs from the region of Caicara, "el sol" and "la luna," of which the writer saw only "el sol," neither he nor any other traveler who ever touched that point seem to have known any of the stone-carvings found by the writer. These newly discovered petroglyphs occur on the banks of the Orinoco and in the adjacent forest. They may be divided up into three distinct groups, one representing the simplest type and consisting of almost geometrical circles, one in the other, the center of the most inner one being hollowed out; another group of a more complicated type and of more fantastic design, of which only one figure was found; and a third group that evedently represents the highest type in the development of this art of petroglyphy and that comprises "el sol," that was already known to Humboldt, and the new petroglyph that was discovered by the writer, namely "el tigre." All these petroglyphs are supposed to have been produced in prehistoric times. As to their meaning there exists quite a number of theories. The writer holds the view, on the base of extended studies in fetichism, that they represent records of earlier and later fetichism, while they have served, at the same time, as an indirect means to develop the art of sculpture that grew out of the art of petroglyphy.

The Work of the State Laboratory of Hygiene, C. A. Shore.

Some Reduction Phenomena in Hydroids, H. V. Wilson.

Some New Questions Concerning Ventilation, C. W. Edwards.

Solution of the Draftsman's Difficulty, John F. Lanneau.

George Marcgrave, the First Student of American Natural History, E. W. Gudger.

George Marcgrave was a member of the Dutch expedition to Brazil under Johann Moritz, Count of Nassau-Siegen, during the first half of the seventeenth century. He assiduously

studied the animals and plants of Brazil during the years1638-1644. In 1648 his drawings and observations, under the title *Historiae Rerum Naturalium Brasiliae* were published jointly with the *De Mericina Brasiliensi* of William Piso under the general title *Historia Naturalais Brasiliae.* Marcgrave's part of this work covers 303 folio pages, in which he describes 301 plants, with 200 figures and 367 animals, of which 222 were figured. Of these 668 forms practically all were new to science and probably none of the 422 figured had ever been drawn before.

Marcgrave knew nothing of the classification of flowers based on stamens and pistils, or of fishes by the count of fin rays, but his descriptions are, for the times, remarkably clear and his drawings sufficiently exact for the plant or animal to be unmistakably recognized. No country in its early exploration has ever had such a great work published on its natural history.

A complete biography of Marcgrave is nearly finished and will shortly be offered for publication.

The Electrical Resistance of a Flowing Conductor, A. H. Patterson and V. L. Shrisler.

Capture of Raleigh, N. C., by the Wharf Rat, C. S. Brimley. [Published in full in this issue.]

The Water Molds of Chapel Hill, N. C., W. C. Coker.

Further Notes on the Geology of the Carolina Coast Line, Collier Cobb.

Transient Electrical Phenomena and their Relations to Modern Problems in Electrical Engineering, P. H. Daggett.

The Toxic Action of Haematin and Bile, W. H. Brown.

Notes on the Maturing of Bermuda Grass Seed, O. J. Tillman. [Published in full in this issue.]

Studies of Cotton Seed Meal Intoxication as to Pyrophosphoric Acid, W. A. Withers and B. J. Ray.

E. W. GUDGER, *Secretary.*

ZOOLOGY IN AMERICA BEFORE THE PRESENT PERIOD.*

By H. V. Wilson.

Zoology deals with the *phenomena* of animal life. A necessary and usually early step in the progress of this science in any quarter of the world is to discover and distinguish the kinds of animals — the species, as we say — there found. These in time become the objects of more and more intense and analytical study.

The earliest extant record of our fauna, as far as I know, consists of a series of water-color sketches made by John White, a member of the expedition which made the first settlement on Roanoke Island (1585), and governor of the second Roanoke Island colony. White's pictures, now preserved in the British Museum, show a number of our birds, fishes, insects, also plants and the appearance of the native inhabitants. Even before this, descriptions of some of our native forms, with specimens, had reached learned Europeans interested in science.

In the seventeenth century the French missionaries gave further information of this kind, included in the accounts of their travels. A few of the settlers, too, were sufficiently informed to deal with such matters. Thus John Winthrop, son of the first governor of Massachusetts, and himself governor of Connecticut, was a regular correspondent of the Royal Society. We owe an early record entitled "New England's Rarities" (1672) to an English traveller, John Josselyn, who mentions a good many of our vertebrates, some mollusks and crustacea, also some lower forms such as the star-fish and sea-nettle (jelly fish). Another Englishman, John Lawson, in his History of North Carolina (1714), mentions a number of our animals. His remarks concerning them are often interesting. Buffaloes, he says, he has known to be killed on the hilly part of the Cape Fear river. Beavers were numerous in North Carolina at that time, and whales were abundant off the coast. He lists under

*Presidential address before the North Carolina Academy of Science, April 26, 1912.

the insects (!) alligators, some lizards, several snakes and turtles. He mentions the bull-frog and remarks on the character of his voice. Lawson also mentions some invertebrates: crawfishes, "muscles," the stone crab, the common edible crab, clams, the conch, and the peculiar egg cases of the latter.

Much the most comprehensive and valuable of the early accounts of our fauna is to be found in Mark Catesby's Natural History of Carolina, Florida, and the Bahama Islands. This great work was republished twice. The first volume of the first edition came out in 1732. Catesby, an Englishman, spent several years in this country, and in his beautiful folio plates we find faithful pictures of many of our present wild neighbors.

The eighteenth century, which saw Franklin's remarkable inquiries into the nature of electricity, brought out a few contributions to zoology from native Americans. John Bartram, more specially known as a botanist, should not be forgotten. Bartram, who was a Quaker farmer in Pennsylvania, made good observations on our plants, animals, and fossils. These are described in a long series of letters (1734-1810) and in a journal. Most of Bartram's letters and his journal were sent to Peter Collinson, an English naturalist, who communicated selections to the Royal Society. Bartram was made King's Botanist in 1765 with an annual salary of fifty pounds. It is worthy of note that he was using a microscope in his study of plants in 1754. John Bartram's son, William Bartram, was a well known naturalist in his time. He published a volume of Travels in the Carolinas, Georgia, and Florida in 1791, and is said to have assisted Wilson in the production of his American Ornithology. At the close of the eighteenth century we also find natural history publications of some importance by B. S. Barton.

In the early years of the nineteenth century (1808-14) appeared an important work, important even today, on our birds: Wilson's Ornithology. Wilson was born and bred in Scotland. Another foreigner, Prince Charles Lucien Bonaparte, is the author of an Ornithology supplementary to Wilson's. This was published with some supervision from Americans, Say and

Godman, 1825-33, in this country. One of the earliest technical papers of any considerable importance by a native American is Thomas Say's Crustacea of the United States (1817-18). The first comprehensive work on natural history by a native born American is Dr. Richard Harlan's *Fauna Americana,* bearing the date 1825. This was followed by a valuable work on insects, Thomas Say's American Entomology (1824-28), and by Dr. John D. Godman's three volumes on North American mammals, (1826-28). Barton, Harlan, and Say were natives of Philadelphia, and the two former taught in medical schools in that city. Say's father was a physician and apothecary. He himself was engaged in business, unsuccessfully, in Philadelphia, and later in one of the several attempts made to establish an ideal community — in this case, in New Harmony, Indiana. Godman was born in Annapolis, Maryland, and taught in several medical schools. These early naturalists have the personal interest attaching to pioneers, and it will be seen that in America, as elsewhere, zoology in its beginnings was frequently linked with the profession of medicine. The prominence of Philadelphia as an early zoological centre should be noted. The Academy of Natural Sciences of that city, which has since become so famous, was founded in 1812, Say joining the society in that year.

With the appearance of the works just mentioned, the study of natural history, viz., the description of species with accounts of habits and local distribution, was well under way. In 1827 Audubon began to publish his famous and beautifully illustrated volumes on the "Birds of America." Isaac Lea started a long series of contributions on the classification, anatomy, and embryology of fresh water mussels in 1829. Say's Shells of North America appeared in 1830, Conrad's American Marine Conchology in 1831. Nuttall's Manual of Ornithology of the United States and Canada came out in 1832-34. The four volumes of the first edition of Holbrook's North American Herpetology were published 1836-40. This work, a well known classic dealing with the amphibia and reptiles, and ranking with Audubon's Birds among the early achievements of Amer-

can science, had for its author a South Carolinian, John Edwards Holbrook, Professor of Anatomy in the Medical College of the State of South Carolina. Holbrook was an excellent naturalist, a man of eminence. We learn from his list of honors that he was a member of the Royal Medical Society of Edinburgh, of the Philadelphia Academy of Sciences, and of the Lyceums of Natural History in New York, Boston, and Baltimore. It is noteworthy that in Philadelphia, New York, and Boston the local lyceum or academy of that early time has become a strong institution, supporting and publishing investigations and serving as an instrumentality for the cultivation of the public.

In the decade of 1840-50 a number of works of importance appeared. Much the most imposing is De Kay's Zoology of New York in five large, well illustrated volumes. This widely used work contains descriptions of all the animals known at the time to occur within the state of New York, together with brief descriptions of those occasionally found near the border of the state. These volumes form a part of a general Natural History of New York descriptive of minerals, geological formations, soils, and of the plants and animals of the state. The publication was the outcome of the passage of a bill in 1836 calling for a complete geological survey of the state. For the purposes of this survey the sum of $130,000 was appropriated. The first volume of the report was published in 1842. It includes a description of the mammals, together with a long and historically interesting introduction which embodies a geographical and political history of the state, together with sketches of its colleges and schools, its press, its learned professions, laws, material improvements, etc. The introduction includes also (I quote) "an account of the studies and productions of our citizens in the departments of history, classical learning, mathematical science, pure and mixed biography, travels, romance and general literature, poetry and the fine arts; and of researches in our zoology, botany, meteorology, chemistry and mineralogy; with an account of the inception, progress, and consummation of the survey, to which those researches gave

birth." The result is a picture of a strong, ambitious state, moving rapidly along the path of progress. Wm. H. Seward is the author of the introduction and he remarks that "This review, although circumscribed and imperfect, furnishes gratifying proof that a republican government is not unfavorable to intellectual improvement." Seward, in speaking of the history of geology and geological surveys in this country, calls to mind (I quote) that "North Carolina has the honor of having been the first to send geologists into the field. Professor Olmstead's report upon the economic geology of that state was published in 1825." I may add that the work of our State Survey in making known the natural resources of North Carolina has kept step with the general progress of the state since Olmstead's time. It never was so efficient as under the direction of its present head, Dr. J. H. Pratt, and his immediate predecessor, Dr. J. A. Holmes. As a pleasing piece of testimony, I call to mind the beautiful volume on the Fishes of North Carolina, from the pen of Dr. H. M. Smith, published in recent years as a state document by the Survey. In leaving De Kay's Zoology, which reflects such credit on a great state, let me mention that New York at that time (U. S. Census 1840), contained only 2,428,921 inhabitants.

Shortly after De Kay's work, appeared (1846-49) J. D. Dana's report on the Zoophytes of the Wilkes Exploring Expedition which the U. S. Government had sent out into the Pacific ocean, 1838-42. Dana's descriptions of these simple marine forms made a volume which took place along with the best European work of its sort. In the same decade appeared Gould's Invertebrata of Massachusetts (1841), Haldeman's Monograph of the Pond-snails of the U. S. (1841-44), Audubon and Bachman's Quadrupeds of America (three volumes, 1846-54), Storer's Synopsis of the Fishes of North America (1846).

Up to this date the work of zoologists in America had been almost completely restricted to the field of systematic zoology, viz., they had been engaged in the description and classification of species and, more incidentally, with habits and distribution. In 1846 came the already famous Swiss naturalist, Louis

Agassiz, to this country. He came primarily to deliver some lectures in Boston. Agassiz's personality captivated the country and, although he freely criticised it, the country evidently captivated him, for he remained here until his death in 1873, refusing offers, of the most attractive kind, of posts in European institutions. Agassiz himself was a systematic zoologist, a describer and classifier of high rank, but he was much more. He brought with him a practical familiarity with the problems and points of view of morphological zoology which had been engaging the attention of the great European naturalists for decades. His mind and methods were comparative, and he emphasized the importance of looking not so much at species, as at the fundamental points of structure in the anatomy of groups, the changes of form undergone during embryonic development, and the structure of extinct forms. Moreover, he laid stress on the importance of looking at these three sets of phenomena together. He maintained more definitely than any of his predecessors that the embryo passes through a series of changes during which it resembles successively the lower members of the great group or type to which it belongs; and that the fossils in any group as we proceed from the oldest to the more recent, show a similar progress from simplicity to complexity of structure. How like an argument for evolution all this sounds! But Louis Agassiz to the last held out against evolution, and refused to see that the parallelisms or fundamental similarities between the series of fossils, of existing forms, and of embryonic stages, were to be explained as the result of kinship. Following Cuvier he looked on the history of the world as divisible into a series of distinct epochs, each of which was inaugurated by a special act of creation. The several epochs with their living organisms were brought to a close by tremendous, supernaturally induced disasters styled cataclysms. Between the species of two epochs there could be, he maintained, no kinship, no material or genetic connection. Whatever resemblances existed between species were, to his mind, purely ideal and due to the fact that organisms represent the embodied thoughts of a superior power. This way of look-

ing at the living world seems strangely archaic, poetic, to us who have every reason to believe that all material phenomena are due to material causes, and that resemblances between natural species, living and fossil *are* material phenomena and of the same kind as resemblances between such races as have been produced from a common stock through man's selective breeding. Agassiz's interpretation of the parallelism between anatomical, paleontological, and embryological facts, obviously must be classed in that group of hypotheses which make immediate appeal to hyperphysical powers in order to explain natural phenomena.

But although today we can only look on Agassiz's theorizing as we look on poetry, we see beneath this cloudy mantle a great man and a master in science, one who exercised a strong and beneficial influence on American zoology and American science in general through his constant injunction to compare and so learn what is general, what is fundamental.

As new ideas come into a science, new fields of investigation are opened, but the old ones are not necessarily closed. And, as we very well know, the study of systematic zoology did not come to an end with the advent of the Agassiz period of comparison and transcendental interpretation, nor later with the advent of the evolution idea, nor later still with the oncome of the present era of analysis and experiment. On the contrary, along with the rise and development of the many comparative and experimental branches of modern zoology, the description and tabulation of the earth's fauna has gone steadily on, and is today progressing as actively as ever. It is pleasant to think that members of our own society are helping in this piece of the world's work. When we come to think how imperfect is our knowledge, even today after so much labor, as to the kinds of animals that live with us in garden and orchard, in wood and meadow, in pond and stream, and above all in the sea, naturalists realize what a vast deal of work stands before the describers and classifiers. Everywhere search reveals new forms. As to the place of these in classification how difficult it often is to decide. We know that species are not the immutable things Lin-

naeus had in mind. They are only groups of individuals subject to the transforming influence of many factors. Ideally the systematist when he lists his form should not only be able to pick out its characteristic points, but through comparison of many live individuals from different localities and through experiment he should know whether such characteristics are produced and maintained through the continuous action of food, climate, or other environmental influences; or whether they are ingrained in the constitution of the race, viz., hereditary, and so in some degree independent of the environment. Should the characteristics prove hereditary, the relation of the new form to other closely similar "kinds" should be determined, before the form in question is listed as species, subspecies, mutation, or what not. If the systematist should carry out this ambitious program for all the kinds of animals he encounters, his task would indeed be stupendous. For the most part he must be content with listing his kinds in such wise as to make it a known and accessible fact that a form of definite anatomical peculiarities occurs in such and such a region. This done, he has advanced science measurably, and may leave it to others, or to himself in another capacity, to select from the vast mass of species certain ones for intensive study of a comparative and experimental character.

Many of the ablest and most highly praised pieces of zoological work emanating from America have been memoirs in systematic zoology. But it should be added that such memoirs show us that great success in classification requires a wide and deep knowledge of the group to be handled. The classifier should, above all, be familiar with the comparative anatomy and embryology of the group, and with the periodic or other modifications of structure incidental to function, habit, or nature of the home. And this means that he must be familiar with his forms as *living* animals, and that the size of the group be not too large. As representative classics in American systematic zoology I may pick out for mention Audubon's Birds (1827-38), Holbrook's Herpetology (1836-40), Dana's Crustacea of the Wilkes Exploring Expedition (1852), Louis Agassiz's Memoirs

on jelly fish and hydroids (1860-62), Leidy's Monograph on the amoeboid protozoa or Rhizopods (1870), Alexander Agassiz's Revision of the sea-urchins (1872), and the three reports by A. Agassiz, Lyman, and Brooks (1882-86), on the sea-urchins, ophiuroids, and stomatopod crustacea, collected by the British ship "Challenger" on her famous voyage of scientific exploration.

One of Louis Agassiz's strong predilections was for the study of embryology. The influence of his example and teaching in Cambridge and in Charleston, during his winter visits to that city, is apparent when we run through the list of American publications in zoology. Up to the time of Agassiz's arrival, practically no embryological investigations had been carried on in this country. But now we find during the period 1846-73 a very considerable number of investigations of this character going on, emanating from Agassiz himself, his associates, students, and ex-students. Agassiz studied the development of jelly fish, hydroids, and turtles. McCrady made important observations on the development of the jelly fish found in Charleston harbor. Alexander Agassiz, the son of Louis, a great naturalist who has but recently died, studied the development of ctenophores, starfishes, and annelid worms. Morse investigated the embryology of the brachiopods. Packard made known striking facts in the development of Limulus, the kingcrab or horse-shoe crab.

As it was with the study of embryology, so it was with the study of fossils. Agassiz's comparisons awakened interest and led to investigations. The most celebrated of these came from Leidy, Professor of Anatomy in the University of Pennsylvania, and dealt with the fossil vertebrates found imbedded beneath our western plains. These studies of Leidy were the precursors of a long series of discoveries made in later years, especially by Cope, Marsh, and Osborn, which have told us much about the ancient history of our western states.

When the study of embryology and the simpler animals became occupations of intellectual interest in Europe, some of the great naturalists like Johannes Müller, Professor in Berlin, began to make pilgrimages to the sea shore to study, especially

with the microscope, the wonderful phenomena of marine life. Agassiz brought with him to this country the interest in the sea and its organisms. This he spread, and in the last years of his life brought to a focus in the establishment of his famous summer school on the island of Penikese, the first of the marine laboratories now to be found scattered along our Atlantic and Pacific coasts. The Penikese laboratory exerted an immense influence, but served its purpose and ceased to be, unlike that other magnificent institution founded by Agassiz and developed by his great son, the "Museum of Comparative Zoology at Harvard College."

In the midst of Agassiz's career in this country came the publication of Darwin's Origin of Species (1859), and the speedy adoption by the great bulk of the thinking world of the theory of evolution. The ferment of the evolution idea shook America as it did other countries. Similarities such as Agassiz had been interpreting in poetic, transcendental fashion, became matters of more practical concern. The past history of the living world was opened to investigation, and with all the enthusiasm of explorers, ardent spirits on many sides began with fresh energy to dig for fossils, to trace the changes of form undergone by the egg in its course of development, to look for transitional types filling up the gaps between groups, and to study in detail the tissues and organs and plan of body of all animals, low and high, that could tell us anything of general interest about the kinship of groups. It takes an idea to make men work, and evolution was the new idea, more stimulating, more strengthening, as results came in, to the searcher than any of its predecessors. The ancestral history or phylogeny of each group was constructed and reconstructed, and reconstructed again, as new data became available. The data were in kind not different from the discoveries of fundamental similarities of structure, familiar to biologists in the pre-evolutionary epoch, but now they were discovered in places where the earlier naturalists had not looked for them, and even between the great groups or phyla sharp lines were wiped out. Above all the volume of discovery streaming in soon became far greater than

in previous epochs. This remarkably intense interest in the facts of structure, resulting in evolutionary interpretations in the shape of race-histories or phylogenies, was the most dominant force at work throughout the whole range of biology until about 1890. In zoology especially most of the strong, keen minds were active in such investigations.

Science consists primarily of demonstrable facts, arranged in generalizations of more and more comprehensive scope, in such wise as to expose the time relation between the antecedent facts or cause and the sequent facts or effect. These generalizations glued together with theory make up in any age the contemporaneous body of science, which the members of that generation see in the mind's eye when they piece together all they know or have some reason to believe in concerning material phenomena. Naturally as generalizations widen, and theories are verified, disproved, or changed, our mental picture of that stately building of science (to borrow a favorite Germanism) changes too. And so the picture drawn by those of a preceding generation may look in many particulars strangely unlike that which we see today, but if they *were* and we *are* good workers, the next generation will see in the two pictures beneath the superficial dissimilarities much the same basic framework of lines. It is this well known use of theory which exposes us sometimes to the dashing onset of the clever tongued and light minded, who allege that we are no better than others, that we too muddle up fact and fancy. Peace to the satirist and thanks, if only he have humor and not mere impudence! We do *not* muddle, or at any rate (for we are only men) we *try* not to muddle fact and fancy. Nevertheless we certainly eke out fact with fancy, in the shape of hypotheses. But these we must continually try out in the daily round of experience. Do observation and experiment confirm the fancy? we ask. And then we find, or others find, that most of the hypotheses prove untrue and are to be discarded. Some quickly prove true, and if for these we continue to use the term "theory," we do so from habit. So it is with the "cell theory," long ago demonstrated to be fact. Others deal with phenomena of such a kind that we can

not experimentally demonstrate or disprove the theory in its entirety. We then ask if any of the facts of observation and experiment contradict the theory, or do they corroborate it in that they prove explicable by it. And are there many such facts and of diverse kinds? In other words, have we worked with the theory a long time and found it to hold good? If so, after a time we practically cease to question it directly, and it comes into a use that is habitual and almost reflex. So it is with the theory of universal gravitation and so it is with the theory of organic evolution.

A gulf separates Agassiz's theory from that of evolution, and yet we must recognize that the actual investigations of the earlier school, the solid discovery of demonstrable facts and their formulation into generalizations, went on along much the same lines as in the later period. We may therefore with justice say that in America from about 1850 to 1890 it was the interest in fundamental form that dominated zoology. This was the great period of morphology to which zoology owes so much, and which began in Europe in the early years of the nineteenth century. Many of the most substantial results of biological inquiry have resulted from this intense comparative study of structure, adult and embryonic. That the body of all but the simplest animals, the protozoa, is composed of tissues, and these of microscopic units, the cells, each of which is comparable with a protozoan; that the egg from which a metazoan animal starts is but a single cell, and that this by division produces many cells which differentiate into the nerve, muscle, gland, and other tissues; that the cells early become arranged into two primary layers, which as such make up the body of low metazoa (coelenterates), but which in higher forms become infolded and outfolded so as to give rise to many internal organs: these are fundamental discoveries which, as Oscar Hertwig has said, are the answers to questions that baffled the most acute biologists and philosophers of earlier ages.

The bulk of the discoveries of morphologists are, of course, such as require for their comprehension some technical training. All I can say here is that this wealth of knowledge, so

comprehensive and detailed, forms an immense part of the safe, secure basis on which rest all the biological inquiries of today. As to the part that American zoologists have played in the development of morphology, while it cannot be claimed that they brought to light any of the very greatest generalizations, comparable with those of von Baer, Rathke, Haeckel, and Kowalevsky, the world owes to them a large number of acute and important investigations. In addition to the names I have already mentioned in speaking of the progress of embryology, two great Americans, who have recently died, should be referred to here, W. K. Brooks and C. O. Whitman.

It must not be supposed that the work in descriptive morphology is at an end. By no means! There is so much to be done that it will doubtless occupy many zoologists for centuries. But as was the case earlier with systematic zoology, so later with pure morphology: it no longer occupies the centre of the stage.

In dealing with evolution I have spoken as if the effort had been solely to reconstruct in the imagination the past world and so to discover the kinship between groups and their place in a natural classification. But along with this inquiry went always the question, What were the *agencies* that have been at work in the transformation of species? This is perhaps the question of more practical concern to us, for the agencies that have been at work in the past are doubtless at work today. It has been *easier,* however, to learn something fairly definite about the *course* of evolution than it has been to determine the factors at work. Moreover, it is doubtless true that a knowledge of lines of ancestry will aid us in the inquiry into the nature of these factors. It is not difficult then to understand why attention was concentrated so long on the data of comparative morphology.

Zoologists and paleontologists have nevertheless speculated abundantly on the causes of transformation, making use of such knowledge as has been available. So in this country Cope, Hyatt, and others have developed theories dealing with these problems. The theories of Cope and Hyatt proceed in part

along the lines laid down by the great French zoologist, Lamarck, and assume that the changes induced in an individual by habit and by the direct action of the environment are inherited. Little, even today, is known on this head, and however suggestive and valuable such theories are, it would seem that nothing certain can be learned from comparison alone. Darwin's theory of natural selection, of the selective influence of the environment, helps us to understand one great, universal attribute of organisms, viz., that structure in general is useful, is adaptive, and again why the descendents of a species should tend to split up into divergent races. But as to the underlying physiological processes concerned in the production of the initial differences between individuals, on which selection operates, it tells us nothing. Nor does it give us information which would enable us even to pick out with certainty the *kinds* of initial differences on which selection can operate. Lamarck, Darwin, and evolutionists in general have all along seen clearly that such problems can only be answered with the aid of *experiment.*

This word, "experiment," is the master-word to the understanding of the present era in zoology, but with the oncome of this era my sketch must come to an end. Wherever we look today, whether to studies revolving round the idea of species, or to those dealing with habit, or with anatomy, or with the tissues, or with the cell, everywhere we find that along with observation and comparison, experiment has entered in. In some fields the new method is easy to practise and is dominant, in others it is difficult and therefore only accessory. With the introduction of experiment it would seem that many questions which have been raised should find an answer. Certainly the outlook is hopeful.

CHAPEL HILL, N. C.

NOTE ON THE FUNDAMENTAL BASES OF DYNAMICS.

By Wm. Cain.

For some years there has been increasing dissatisfaction with the manner of presentation of the fundamental principles of dynamics, as given by text books, particularly for the use of engineering students. From the time of Newton down, mass of a body has been defined as "the quantity of matter in the body"—an admittedly ambiguous term.

Mass is likewise said to equal density times volume, or density equals mass divided by volume, which gives no precise conception of density until the idea of mass is made clear and precise.

Next in order comes the definition, force $=$ mass $\times$ acceleration, which is likewise obscure until mass is quantitatively defined.

However, as an illustration, if a body of mass m is supposed to fall *in vacuo* under the *force of the* attraction of gravitation, whose measure is the weight W in pounds (say), the acceleration being g ft. per second per second, then the above equation takes the well known form,

$$W = mg;$$

whence $m = W/g$

so that finally it is seen that mass is directly proportional to weight and inversely proportional to the acceleration of gravity. Also, since W varies directly as g, the ratio W/g is constant for the same body for all points *on* or *in* the earth, and it is now realized clearly that mass is something pertaining to a body that does not alter with its position.

Now it has always seemed to the writer that it would be more logical to start with this precise conception of mass; in other words, define m as W/g, so that there will be no ambiguity, from the start, in ideas of mass, density and force. If this is done, however, it is very important to explain how W is to be found; for the weight of a body, as estimated by an equal armed balance is not usually the same as that given by a spring balance,

and it is well as a preliminary to the subject of dynamics to precisely describe the two methods of weighing and under what conditions they differ.

In what follows, the writer desires to acknowledge his indebtedness to an article by Prof. William Kent in " Science" for May 5th, 1911, entitled, " Notes on the Preliminary Report of the Committee on the Teaching of Mathematics to Students of Engineering." The present article might very well bear the same title, for its inspiration has come through reading the parts of the report given by Professor Kent and his valuable criticism thereon. The great value of the Report and Notes in outlining a method of presenting the first principles of dynamics, is acknowledged. But the writer believes the matter can be cast into a simpler and more logical form and he will endeavor, in what follows, to carry out this idea by suggesting such an outline of parts of the subject where amendment seems desirable.

(1) Mechanics treats of matter, at rest or in motion, under the action of force.

(2) The phrase, "weight of a body," is unfortunately used in two senses (1) to indicate the quantity of matter in the body, (2) to mean the force of attraction of the earth at the place on the body. To avoid confusion it is often advisable to specify the meaning intended. Thus a piece of matter weighing a pound may be called a pound of matter or a pound mass, whereas the force of attraction of the earth on it will be called a pound force. Similarly we can speak of a ton of matter and a ton force.

(3) The "British Unit" of weight is the quantity of matter in a certain piece of platinum and is called a pound. The "French Unit" is called the kilogram.

Copies of either standard, together with multiples and fractional parts of the same, will be called "a set of standard weights."

(4) To weigh a body on *an equal armed balance,* the body is put in one scale pan and is balanced by a certain number of standard weights (metal pieces) in the other scale pan. By this method, it is seen that the body will "weigh" the same at any latitude or altitude. Since the attraction of the earth on a

body varies both with the latitude and altitude, it is evident that the equal armed balance does not indicate, everywhere, the attractive force of the earth on the body.

The same remark applies to any lever balance or platform scales.

(5) Suppose a *spring balance* to be graduated with a set of standard British weights at sea level at latitude 45° where $g = 32.174$ ft. pr. sec. pr. sec. is the acceleration due to gravity. Now suppose a certain body there, when hung from the spring balance, to depress the pointer until it reads W lbs., then the attraction of the earth, at this point, for the body is exactly W pounds force.

Similarly, if the body is hung from this same "standard" spring balance at any other point on the earth, although the pointer may not read the same as before, still it indicates exactly the force with which the body is attracted by the earth at the place. This is the *true weight* of, or the pull of the *earth* on, the body and is the only one to be considered where great scientific accuracy is required.

(6) Call the weight of the body at the second place W_1 and the acceleration due to gravity g_1 ft. pr. sec. pr. sec.; then since it is an Experimental Fact that weight varies with acceleration,

$$\frac{W_1}{g_1} = \frac{W}{g} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

This simple equation gives the solution to a number of problems involving weights at different latitudes.

(7) Thus, if the standard spring balance has been graduated at sea level at latitude 45° and a body weighs there W pounds, it will weigh at the equator, at sea level, where $g = 32.0894$,

$$W_1 \quad \frac{32.0894}{32.174} W = 0.99737\, W \text{ (lbs.)}$$

If $W = 10000$ lbs., $W_1 = 9973.7$ lbs., a difference of only 26.3 lbs. in 10000; so that for ordinary commercial or engineering purposes the difference is negligible. It is to be noted that the

body which weighs 10000 lbs. at 45° latitude, will weigh, on an equal armed balance, 10000 lbs. anywhere. Such a balance, or any lever balance, will thus give approximate results, which are usually near enough for commercial or most engineering purposes.

(8) To find the difference in weights as measured on "the standard spring balance" at any two points, let W_1 and g_1 represent the weight and gravity acceleration at one point, W_2 and g_2 similar quantities for the other point; then,

$$\frac{W_1}{g_1} = \frac{W_2}{g_2} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Thus if a quantity of tea weighs $W_2 = 1$ lb. at the equator, where $g_2 = 32.09$, it will weigh at London where $g_1 = 32.19$

$$W_1 = \frac{32.19}{32.09}(1) = 1.003 \text{ lb.}$$

(9) Similarly, if any heavy body suspended from a wire, stretches it an amount e at the equator, it will stretch it $1.003e$ at London.

(10) The steam pressure that will just lift a certain body at London, will be 1.003 times the steam pressure, at the same temperature, that will lift the same body at the equator. Otherwise, by proportion, the *same* steam pressure will lift a body at the equator weighing 1.003 times as much as at London, if the weighing, in this instance, is done on an equal armed balance or its equivalent at both places. In fact, adopting the notation of (8), if the steam can just lift a body weighing W lbs. on the *spring balance* at London, by assumption, it exerts the same pressure,

$$W_1 = \frac{g_1}{g_2} W_2 = \frac{32.19}{32.09} W_2 = 1.003\, W_2$$

at the equator.

Here W_2 is the spring balance weight of the same body at the equator. Hence a second body weighing 1.003 times the

first will just be lifted by the same steam pressure at the equator.

(11) Another simple illustration will be given. The work of raising a body of weight W lbs. at sea level, at latitude 45°, h feet, is (Wh) ft. lbs. At this place, call the acceleration due to gravity g, at a second place g_1; whence the attraction of the earth on the same body at the second place is by (1)

$$W_1 = \frac{g_1}{g} W$$

Hence the work of lifting it, at the second place, is, in ft. lbs.,

$$W_1 h = \frac{g_1}{g} (Wh)$$

(12) MASS. Mass of a body means the quantity of matter in the body, which is not supposed to alter in amount by changing the position of the body relative to the earth or to be affected by the expansion or contraction of the body. Body here refers to a limited portion of a gas or liquid or any solid body.

Now by the experimental law, eq. (1) the ratio W/g of the weight of the body, as given by a spring balance, to the acceleration due to gravity at any point within the sphere of the earth's attraction, *is constant.* Hence *mass,* which is likewise unalterable by a change of place, is proportioned to W/g.

In the engineers' system it is usual to write for the mass m, the equality,

$$m = \frac{W}{g} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

so that, in this system, W/g can be regarded as the measure of the mass. For the same place, it varies directly with the weight.

We have now a precise measure of mass and can appreciate what properties of matter the word mass includes.

(13) The term *"density"* can now be defined as the quotient of mass by volume.

(14) The word *"force"* may be simply defined as a push or a pull.

(15) From sq. (3), we have, $W = mg$.

The fundamental formula of mechanics is,

$$F = m\,a \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\quad (4)$$

where F is the force acting on the body whose mass is m and acceleration a, the force and acceleration being in the same direction.

In the engineers' system of units, when gravity is the force, acting (of course, vertically) $F = W$ lbs., $a = g$, giving the previous formula as a special case of (4).

(4) can likewise be written,

$$F = \frac{W}{g}a \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\quad (5)$$

where F and W are expressed in pounds, a and g, in feet per second per second.

(16) From (4) other well known formulas as, $F\,t = m\,v$; $F\,s = \frac{1}{2}\,m\,v^2$, can at once be derived.

(17) Newton's three laws may be stated and commented on at this stage. Formula (4) is the symbolical expression of one law. Let us make an immediate application of the third law, "to every action, there is always an equal and contrary reaction."

Thus let a perfectly smooth particle of mass m strike a second similar particle of mass m, both moving in the same direction along the lines of the centers of the particles. In the infinitesimal time dt, call the accelerations of the particles a and a_1 respectively, since they act in opposite directions, a and a_1 have opposite signs. When by Newton's law of action and reaction

$$-\,m\,a = m_1\,a_1\,; \quad \frac{m}{m_1} = -\frac{a_1}{a}$$

In a recent work on Analytic Mechanics by Barton, p. 196, the author follows Mach in giving the last equation as a definition of mass. It is submitted that it is simpler to define mass as in (12), then force as in (15), whence the above formula is seen to be a derived one.

(18) In formula (5) above, W is supposed to be the weight of the body in pounds as determined by a standard spring balance, used at the place of the body. By formula (1), W can be taken as the weight by spring balance at 45° latitude, provided g is put = 32.174. But W will be the same if the body is weighed on an equal armed balance anywhere (4); hence, supposing the body weighed in the usual way on a lever balance, formula (5) can be written in the exact form,

$$F = \frac{W}{32.174} a \quad \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

This is evidently the most practical form of equation (5).

(19) BRITISH ABSOLUTE SYSTEM. In the British engineers' system, with which we have dealt so far, the pound weight at sea level at latitude 45° has been taken as the unit of force and the unit mass is derived from the equation

$$m = \frac{W}{32.174} = 1;$$

whence the unit mass is the mass of a body weighing 32.174 lbs. on a standard spring balance at sea level, at 45° latitude, or on a lever balance anywhere. In the *British absolute system* the mass of the piece of metal, called a pound weight, is taken as the unit of mass, and the unit of force is defined as that force which, acting for one second on the mass of the pound piece of metal generates in it a velocity of one foot per second.

From numerous experiments it is known that if a body weighing one pound, on a lever balance, fall freely for one second, at sea level, at latitude 45°, it will acquire a velocity of $g = 32.174$ feet per second. The force acting on the body is 1 pound. If this force was $\frac{1}{g}$ of a pound, the body at the end of one second, would have a velocity of one foot per second. Hence the unit of force, at the place, is $\frac{1}{g}$ of a pound (force)

or slightly less than half an ounce avoirdupois. Such a force has been called a *poundal.*

By equation (1) putting $W = 1$, $g = 32.174$, we have

$$\frac{W_1}{g_1} = \frac{1}{32.174},$$

In this equation, W_1 represents the attraction of the earth on the metal piece, called a pound weight, at any place where the acceleration is g_1. Reasoning as before, the force W_1 acting freely on the metal piece will cause it to acquire in one second a velocity of g_1 feet per second; hence the force

$$\frac{W_1}{g_1} = \frac{1}{32.174} \text{ pound} = 0.031081 \text{ pound},$$

will produce in the body a velocity of one foot per second at the place considered. The unit of force, the poundal, in the absolute system, is thus constant and it may be thought of as a pull or a push of a little less than ½ ounce. Let the student realize that in the absolute system, in connection with the formula $F = m\,a$, that m is expressed by the same number that represents the weight in pounds of the body as found (anywhere) by an equal-armed balance, and that F is expressed in poundals, where a poundal is 0.031081 pound force.

An answer in poundals can be readily expressed in pounds of force by dividing by 32.174 or multiplying by 0.031081. In Technical Mechanics, it is well to give the absolute system in an Appendix, for although the engineer student will not use it in his ordinary work, still a slight study of the absolute system will enable one to read valuable works that otherwise might offer difficulties.

The same remarks apply to the French C. G. S. system, which may be analyzed as above. It is well to bear in mind that in any absolute system, the lever balance always measures mass, whereas in the engineers' system the spring balance measures the attraction of the earth (weight).

CHAPEL HILL, N. C.

NOTES ON THE DISTRIBUTION OF THE MORE COMMON BIVALVES OF BEAUFORT, N. C.

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While studying for systematic purposes the approximately ninety species of bivalve molluscs which are found in the vicinity of the Fisheries Laboratory at Beaufort, N. C., it seemed desirable to consider which were available for scientific work involving the use of living animals. A species represented at the laboratory by a few specimens dredged in the deeper water offshore, or by valves secured on the beaches, would be useless for such research. Also species which might be abundant in the vicinity but of which the habitat is not sufficiently well known to permit of their being collected when wanted would be equally useless. It is the purpose of this paper to indicate which species are available in a living condition, specific localities where they may be found, and when possible something in reference to their abundance. A paper of this kind cannot be complete, for further work will necessarily extend such information. It can only include what is known at the time by the writer. It is hoped that it may be of service to prospective investigators by pointing out what material they would have at their service under ordinary conditions.

For the identification of the species and for assistance with the literature I am very largely indebted to Doctors Dall and Bartsch of the U. S. National Museum.

FAMILY SOLENOMYACIDÆ.

Genus Solemya Lamarck, 1818.

Solemya velum Say.

Solemya velum Say, Journ. Acad. Nat. Sci. Phila., vol. 2, p. 317, 1822.
Solenomya velum, Dall, Bull. 37, U. S. Nat. Mus., p. 46, fig. 3, 1889.

Abundant on the sandy shoals west of the laboratory. Early records indicate that it is found on Bird Shoal. It has been

found recently near Gallants Point across the channel leading from the inland waterway to Beaufort, and it probably occurs on sandy shoals throughout the vicinity. It is easily obtained at low water, living in sand near the surface. Collected on Shark Shoal, 1912.

FAMILY NUCULIDÆ.

Genus Nucula Lamarck, 1799.

Nucula proxima Say.

Nucula proxima Say, Journ. Acad. Nat. Sci. Phila., vol. 2, p. 270, 1822; Dall, Bull. 37, U. S. Nat. Mus., p. 42, pl. 56, fig. 4, 1889; Dall, Trans. Wagner Inst. Sci., vol. 3, pt. 4, p. 574, 1898.

Little attention has been given to the collection of living specimens. Live animals have been dredged, during 1912, near the eastern end of Bogue Sound, and dead valves are found in other localities. It is believed that careful search would yield abundant material.

FAMILY ARCIDÆ.

Genus Arca (Linnæus) Lamarck, 1799.

Subgenus Noëtia Gray, 1840.

Arca (Noëtia) ponderosa Say.

Arca ponderosa Say, Journ. Acad. Nat. Sci. Phila., vol. 2, p. 267, 1822.

Arca (Noëtia) ponderosa, Dall, Bull. 37, U. S. Nat. Mus., p. 40, 1889; Dall, Trans. Wagner Inst. Sci., vol. 3, pt. 4, p. 633, 1898.

Of the several species of this genus which belong to the Beaufort fauna this is the most abundant. It is a large form and may be readily obtained at any time. It lives a few inches below the surface of the ground, in firm sand or mud. One specific collecting ground is the shoals west of the laboratory.

Subgenus Scapharca (Gray) Dall.

Arca (Scapharca) transversa Say.

Arca transversa Say, Journ. Acad. Nat. Sci. Phila., vol. 2, p. 269, 1822; Dall, Bull. 37, U. S. Nat. Mus., p. 40, pl. 56, fig. 2, 1889.

Scapharca (Scapharca) transversa, Dall, Trans. Wagner Inst. Sci., vol. 3, pt. 4, p. 645, 1898.

Several specimens in the laboratory collection are recorded as having been collected above Horse Island on mud bottom. The animal, immature, is recorded from Pivers Island and from Bogue Sound. A few other specimens have been taken in the dredge in the vicinity of Beaufort. Valves are found rather commonly.

Arca (Scapharca) campechensis Dillwyn.

Arca campechensis Dillwyn, Descr. Cat. Rec. Sh., I., p. 288, 1817 (Syn. partim exclus.), Jamaica and Carolina.

Arca pexata Say, Journ. Acad. Nat. Sci. Phila., vol. 2, p. 268, 1822; Dall, Bull. 37, U. S. Nat. Mus., p. 40, 1889.

Scapharca (Argina) campechensis, Dall, Trans. Wagner Inst. Sci., vol. 3, pt. 4, p. 650, 1898.

Small examples have been dredged in Bogue Sound; one specimen in channel south of Green Rock. As many valves are in the laboratory collection, further search will probably reveal good collecting grounds.

FAMILY PINNIDÆ.

Genus Atrina Gray.

Atrina rigida (Dillwyn).

Pinna rigida (Solander MSS.) Dillwyn, Cat., p. 327, 1817.

Atrina rigida, Dall, Trans. Wagner Inst. Sci., vol. 3, pt. 4, p. 663, 1898; Grave, B. H., Bull. Bur. Fish., vol. 29, p. 411, 1911.

The species is fairly abundant. The usual collecting ground is in the vicinity of Pivers Island. The form may be found at about low water mark. The valves usually project a short distance above the surface of the ground.

The anatomy and physiology of this species have been made the subject of a report by Grave, loc. cit.

FAMILY PTERIIDÆ.

Genus Pteria Scopoli, 1777.

Pteria colymbus (Bolten).

Pinctada colymbus Bolten, Mus. Boltenian., p. 167, 1798.

Avicula atlantica, Dall, Bull. 37, U. S. Nat. Mus., p. 36, 1889.

Pteria colymbus, Dall, Trans. Wagner Inst. Sci., vol. 3, pt. 4, p. 670, 1898.

Living animals are occasionally found. Systematic search would probably reveal a moderate number. It is found attached to suitable objects in the water.

FAMILY OSTREIDÆ.

Genus Ostrea (Linnæus) Lamarck.

Ostrea virginica Gmelin.

Ostrea virginica Gmelin, Syst. Nat., p. 3336, 1792; Dall, Trans. Wagner Inst. Sci., vol. 3, pt. 4, p. 687, 1898.

This abundant species needs only inclusion in this list.

FAMILY PECTINIDÆ

Genus Pecten Müller.

Pecten (Plagioctenium) gibbus (Linnæus).

Ostrea gibba Linnæus, Syst. Nat., Ed. 10, No. 172, p. 698, 1758.

Pecten dislocatus Say, Journ. Acad. Nat. Sci. Phila., vol. 2, p. 260, 1822.

Pecten (Plagioctenium) gibbus, Dall, Trans. Wagner Inst. Sci., vol. 3, pt. 4, p. 745, 1898.

This species is found in sufficient quantities to form a local food supply of considerable value. The adult form is free-swimming and may be found at various times in different localities. Some observations on the habits of the varietal form *Pecten dislocatus* Say have been published by Grave, B. H., Biol. Bull., vol. 16, No. 5, April, 1909.

FAMILY ANOMIIDÆ.

Genus Anomia (Linnæus) Müller.

Anomia simplex Orbigny.

Anomia simplex Orbigny, Moll. Cubana, vol. 2, p. 367, pl. 38, figs. 31-33, (1845 Spanish edition), 1853; Dall, Bull. 37, U. S. Nat. Mus., p. 32, pl. 53, figs. 1-2, 1889; Dall, Trans. Wagner Inst. Sci., vol. 3, pt. 4, p. 784, 1898.

The animal is common in the vicinity. One collecting ground is the shoals west of the laboratory. It is found attached to other shells, as *Ostrea, Tagelus, Macrocallista.*

FAMILY MYTILIDÆ.

Genus Mytilus (Linnæus) Bolten.

Mytilus (Hormomya) exustus Linnæus.

Mytilus exustus Linnæus, Syst. Nat., Ed. 10, p. 705, 1758; Dall, Bull. 37, U. S. Nat. Mus., p. 38, 1889.

Mytilus (Hormomya) exustus, Dall, Trans. Wagner Inst. Sci., vol. 3, pt. 4, p. 788, 1898.

This comparatively small species is found in fairly large numbers on the breakwater at Pivers Island, associated with *Modiolus demissus* (Dillwyn). It can probably be found on any of the several breakwaters in the vicinity of Beaufort.

Genus Modiolus Lamarck, 1799.

Modiolus (Brachydontes) demissus (Dillwyn).

Mytilus demissus (Solander MSS.) Dillwyn, Descr. Cat. Rec. Shells, vol. 1, p. 314, 1817.

Modiola plicatula, Dall, Bull. 37, U. S. Nat. Mus., p. 38, pl. 54, fig. 1, 1889.

Modiolus (Brachydontes) demissus, Dall, Trans. Wagner Inst. Sci., vol. 3, pt. 4, p. 794, 1898.

Very abundant on the breakwater and on muddy ground between tide marks at Pivers Island. Abundant about the western end of Town Marsh. Its natural habitat at Beaufort seems to be between tide marks among the roots of vegetation along the edges of salt marshes. It is the common mussel at Beaufort.

Modiolus tulipus Lamarck.

Modiola tulipa Lamarck, An. sans Vert., vol. 6, p. 111, 1819; Dall, Bull. 37, U. S. Nat. Mus., p. 38, 1889.

Modiolus tulipus, Dall & Simpson, Bull. U. S. Fish Com. for 1900, vol. 20, pt. 1, p. 470.

The species has been found at the railroad pier at Morehead City and in the vicinity of Pivers Island. So far living material has not been found abundantly.

Genus Lithophaga Bolten, 1798.

Lithophaga bisulcata (Orbigny).

Lithodomus bisulcatus Orbigny, Moll. Cubana, vol. 2, p. 333, pl. 28, figs. 14-16, 1847 (Spanish edition and atlas, 1845).

Lithophagus bisulcatus, Dall, Bull. 37, U. S. Nat. Mus., p. 38, 1889.

Lithophaga (Diberus) bisulcata, Dall, Trans. Wagner Inst. Sci., vol. 3, pt. 4, p. 801, 1898.

Living animals are abundant near the Norfolk Southern railroad pier at Morehead City. Their occurrence is not known elsewhere about Beaufort Harbor. The species is found burrowing into pieces of coral and soft rock. The scarcity of suitable material into which the individuals may burrow accounts for the limited distribution about Beaufort. The maximum length noted is 46 mm.

FAMILY TEREDINIDÆ.

Genus Xylotrya Leach.

Xylotrya gouldi Bartsch.

Xylotrya gouldi Bartsch, Proc. Biol. Soc. Wash., vol. 21, p. 211, 1908; Sigerfoos, Bull. Bur. Fish., vol. 27, p. 194, 1908.

This species is found abundantly in wood such as piling, exposed to the action of sea water.

FAMILY PHOLADIDÆ.

Genus Martesia Leach, 1825.

Martesia (Section Diplothyra) smithii (Tryon).

Diplothyra smithii Tryon, Proc. Acad. Nat. Sci. Phila., vol. 14, p. 201, 1862.

Martesia (Section Diplothyra) smithii, Dall, Bull. U. S. Nat. Mus., p. 72, 1889.

A small mollusc, which has been found abundantly at the railroad pier at Morehead City.

FAMILY MACTRIDÆ.

Genus Spisula Gray, 1838.

Spisula similis (Say).

Mactra similis Say, Journ. Acad. Nat. Sci. Phila., vol. 2, p. 309, 1822.

Mactra solidissima var. similis, Dall, Bull, 37, U. S. Nat. Mus., p. 62, 1889.

The living animal is taken in the dredge, but specific localities are not recorded. It has been found, 1912, on the seashore near Fort Macon.

Genus Mulinia Gray.

Mulinia lateralis (Say).

Mactra lateralis Say, Journ. Acad. Nat. Sci. Phila., vol. 2, p. 309, 1822; Dall, Bull. 37, U. S. Nat. Mus., p. 62, pl. 69, fig. 8, 1889.

Mulinia lateralis, Dall, Trans. Wagner Inst. Sci., vol. 3, pt. 4, p. 901, 1898.

The species is found at Pivers Island and on a shoal west of that island. Fairly abundant.

FAMILY SOLENIDÆ.

Genus Solen (Linnæus) Scopoli, 1777.

Solen viridis Say.

Solen viridis Say, Journ. Acad. Nat. Sci. Phila., vol. 2, p. 316, 1822.
Solen (Ensis) viridis, Dall, Bull. 37, U. S. Nat. Mus., p. 72, 1889.
Solen viridis, Dall, Trans. Wagner Inst. Sci., vol. 3, pt. 5, p. 952, 1900.

A few animals have been collected at Beaufort. One specific collecting ground is the shoals west of the laboratory.

FAMILY DONACIDÆ.

Genus Donax (Linnæus).

Donax variabilis Say.

Donax variabilis Say, Journ. Acad. Nat. Sci. Phila., vol. 2, p. 305, 1822; Dall, Bull. 37, U. S. Nat. Mus., p. 58, 1889; Dall, Trans. Wagner Inst. Sci., vol. 3, pt. 5, p. 969, 1900.

The specific collecting ground is the seashore at Fort Macon. At times small areas near the water's edge may be found where the animals occur in large numbers.

FAMILY PSAMMOBIIDÆ.

Genus Tagelus Gray.

Tagelus gibbus (Spengler).

Solen gibbus Spengler, Skrivt. Nat. Selsk., vol. 3, p. 104, 1794.

Tagelus gibbus, Dall, Bull. 37, U. S. Nat. Mus., p. 58, pl. 55, fig. 3, pl. 56, fig. 3, 1889; Dall, Trans. Wagner Inst. Sci., vol. 3, pt. 5, p. 983, 1900.

Collecting grounds: In muddy sand just south of railroad pier at Morehead City, Pivers Island, shoals west of Pivers Island. The animal may be found buried at a depth of a foot or more in the ground between tide marks. Shells are common on Shark Shoal.

Tagelus divisus (Spengler).

Solen divisus Spengler, Skrivt. Nat. Selsk., vol. 3, p. 96, 1794.
Tagelus divisus, Dall, Bull. 37, U. S. Nat. Mus., p. 58, pl. 56, fig 5, 1889; Dall, Trans. Wagner Inst. Sci., vol. 3, pt. 5, p. 984, 1900.

Collecting grounds: Dredging in Bogue Sound, vicinity of Pivers Island, near Gallants Point across the channel leading from inland waterway to Beaufort, south of railroad pier at Morehead City, muddy sand about western end of Town Marsh. Abundant.

FAMILY SEMELIDÆ.

Genus Semele Schumacher.

Semele proficua (Pulteney).

Tellina proficua Pulteney, Hutchin's Dorset, p. 29, pl. 5, fig. 4, 1799.
Semele proficua, Dall & Simpson, Bull. U. S. Fish Com. for 1900, vol. 20, pt. 1, p. 477; Dall, Trans. Wagner Inst. Sci., vol. 3, pt. 5, p. 991, 1900.

The species is common on Pivers Island, and it is also obtained by dredging in Bogue Sound.

Genus Abra (Leach) Lamarck, 1818.

Abra æqualis (Say).

Amphidesma æqualis Say, Journ. Acad. Nat. Sci. Phila., vol. 2, p. 307, 1822.
Abra æqualis, Dall, Bull. 37, U. S. Nat. Mus., p. 62, 1889; Dall, Trans. Wagner Inst. Sci., vol. 3, pt. 5, p. 998, 1900.

It may be obtained by dredging in Bogue Sound. Live material is not recorded as common. Valves of the species appear to be abundant throughout the vicinity of the laboratory.

FAMILY TELLINIDÆ.

Genus Tellina (Linnæus) Lamarck, 1799.

Tellina alternata Say.

Tellina alternata Say, Journ. Acad. Nat. Sci. Phila., vol. 2, p. 275, 1822; Dall, Bull. 37, U. S. Nat. Mus., p. 60, 1889.
Tellina (Eurytellina) alternata, Dall, Trans Wagner Inst. Sci., vol. 3, pt. 5, p. 1029, 1900.

The live animal is found in Beaufort Harbor but specific localities are not recorded.

Genus Macoma Leach, 1819.

Macoma tenta (Say).

? Psammobia lusoria Say, Journ. Acad. Nat. Sci. Phila., vol. 2, p. 304, 1822; not of Conrad, 1840.

Tellina tenta Say, Am. Conch., pl. 65, fig. 3, 1834.

Macoma tenta, Dall, Bull. 37, U. S. Nat. Mus., p. 60, pl. 56, fig. 10, 1889; Dall, Trans. Wagner Inst. Sci., vol. 3, pt. 5, p. 1049, 1900.

Collecting ground: Dredging in Bogue Sound. Material not known to be abundant.

FAMILY PETRICOLIDÆ.

Genus Petricola Lamarck, 1801.

Petricola (Rupellaria) typica (Jonas).

Choristodon typicum Jonas, Zeitschr. Mal., i., p. 185; Beitr. Molluskol., p. 1, pl. 7, fig. 3, 1844.

Petricola (Choristodon) robusta, Dall, Bull. 37, U. S. Nat. Mus., p. 58, 1889; not of Sowerby.

Petricola (Rupellaria) typica, Dall, Trans. Wagner Inst. Sci., vol. 3, pt. 5, p. 1059, 1900.

Collecting ground at railroad pier, Morehead City.

Petricola (Petricolaria) pholadiformis Lamarck.

Petricola pholadiformis Lamarck, An. sans Vert., v., p. 505, 1818; Dall, Bull. 37, U. S. Nat. Mus., p. 58, pl. 59, fig. 15, pl. 64, fig. 140a, 1889.

Petricola (Petricolaria) pholadiformis, Dall, Trans. Wagner Inst. Sci., vol. 3, pt. 5, p. 1061, 1900.

The animal is found in the mud (or turf) in the vicinity of the jetties at Fort Macon; also about the western end of Town Marsh. It lives near the surface between tide marks. It is also found in rocks at the railroad pier at Morehead City.

Petricola dactylus Sowerby.

Petricola dactylus Sowerby, Genera, Petricola, fig. 3, 1823.

Petricola pholadiformis var. dactylus, Dall, Bull. 37, U. S. Nat. Mus., p. 58, 1889.

Specimens are found at the railroad pier at Morehead City. The species is probably more widely distributed in the vicinity.

FAMILY VENERIDÆ.

Genus Dosinia Scopoli, 1777.

Dosinia discus (Reeve).

Artemis discus Reeve, Conch. Icon., vol. 6, Artemis, pl. 2, fig. 9, 1850.

Dosinia (Dosinidia) discus, Dall, Proc. U. S. Nat. Mus., No. 1312, p. 379, pl. 12, fig. 1, pl. 13, fig. 1, 1902; Dall, Trans. Wagner Inst. Sci., vol. 3, pt. 6, p. 1232, 1903.

Material very abundant in the sand flats about Pivers Island. It is found buried in sand nearly a foot below the surface, near the low water mark. It could probably be found on sandy shoals generally in the vicinity.

Genus Macrocallista Meek, 1876.

Macrocallista nimbosa (Solander).

Venus nimbosa Solander, Portland Cat., p. 175, No. 3761, 1786.

Cytherea (Callista) gigantea, Dall, Bull. 37, U. S. Nat. Mus., p. 56, 1889.

Macrocallista nimbosa, Dall, Trans. Wagner Inst. Sci., vol. 3, pt. 6, p. 1254, 1903.

One specific collecting ground is the shoals west of Pivers Island. It is also found on Shark Shoal. Charles Hatsel states that it is common on Bird Shoal and that it lives three or four inches below the surface in sand between tide marks.

Genus Chione Megerle von Muhlfeld, 1811.

Chione cancellata (Linnæus).

Venus cancellata Linnæus, Syst. Nat., Ed. 12, p. 1130, 1767; Dall, Bull. 37, U. S. Nat. Mus., p. 54, 1889.

Chione cancellata, Dall, Trans. Wagner Inst. Sci., vol. 3, pt. 6, p. 1290, 1903.

Specific collecting grounds are about the laboratory pier at Pivers Island and on the old oyster reef across the channel from the east side of Pivers Island. It is a very abundant species, living on muddy or shelly bottom, near or on the surface, at about low water mark.

Genus Venus (Linnæus) Lamarck.

Venus mercenaria (Linnæus).

Venus mercenaria Linnæus, Syst. Nat., Ed. 10, p. 686, 1758.

Venus mercenaria, Dall, Bull. 37, U. S. Nat. Mus., p. 54, pl. 55, fig. 7,

pl. 71, figs. 1, 3, 1889; Dall, Trans. Wagner Inst. Sci., vol. 3, pt. 6, p. 1311, 1903.

The species may be easily obtained at or near the surface on muddy or shelly bottom between tide marks almost anywhere in the vicinity. Very abundant.

FAMILY CARDIIDÆ.

Genus Cardium (Linnæus) Lamarck.

Subgenus Trachycardium Mörch, 1853.

Cardium (Trachycardium) isocardia Linnæus.

<Cardium isocardia Linnæus, Syst. Nat., Ed. 10, p. 679, 1758; Dall, Bull. 37, U. S. Nat. Mus., p. 52, 1889.

Cardium (Trachycardium) isocardia, Dall, Trans. Wagner Inst. Sci., vol. 3, pt. 5, p. 1085, 1900.

The living animal has been dredged, during 1912, near the eastern end of Bogue Sound.

Cardium (Trachycardium) muricatum Linnæus.

Cardium muricatum Linnæus, Syst. Nat., Ed. 10, p. 680, 1758; Dall, Bull. 37, U. S. Nat. Mus., p. 52, 1889.

Cardium (Trachycardium) muricatum, Dall, Trans. Wagner Inst. Sci., vol. 3, pt. 5, p. 1089, 1900.

The species has been collected in the vicinity of Pivers Island, at the railroad pier at Morehead City, and dredged near the eastern end of Bogue Sound.

Subgenus Dinocardium Dall, 1900.

Cardium (Dinocardium) robustum Solander.

Cardium robustum Solander, Portland Catalogue, p. 58, 1786, after Lister, Hist. Conch., pl. 328, fig. 165, 1770.

Cardium magnum, Dall, Bull 37, U. S. Nat. Mus., p. 52, 1889.

Cardium (Cerastoderma) robustum, Dall, Trans. Wagner Inst. Sci., vol. 3, pt. 5, p. 1099, 1900.

Living animals have been found on Bird Shoal in Beaufort Harbor. The valves of this species are the most conspicuous ones on the seashore at Fort Macon.

Subgenus Lævicardium Swainson, 1840.

Cardium (Lævicardium) mortoni Conrad.

Cardium mortoni Conrad, Journ. Acad. Nat. Sci. Phila., vol. 6, p. 259, pl. 10, figs. 5, 6, 7, 1830.

Cardium (Liocardium) mortoni, Dall, Bull. 37, U. S. Nat. Mus., p. 54, pl. 58, fig. 8, 1889.

Cardium (Lævicardium) mortoni, Dall, Trans. Wagner Inst. Sci., vol. 3, pt. 5, p. 1111, 1900.

The live animal may be obtained on Pivers Island, on the shoals west of that island, and in the dredge in the vicinity of Beaufort.

Family Lucinidæ.

Genus Phacoides Blainville, 1825.

Phacoides (Parvilucina) crenella Dall.

Phacoides (Parvilucina) crenella, Dall, Proc. U. S. Nat. Mus., No. 1237, Synopsis Lucinacea, pp. 810, 825, pl. 39, fig. 2, 1901.

Lucina crenulata, Dall, Bull. 37, U. S. Nat. Mus., p. 50, 1889.

Living material could probably be found abundantly, but the laboratory records are not sufficient to verify the assumption. A rather small species.

Genus Divaricella von Martens.

Divaricella quadrisulcata (Orbigny).

Lucina quadrisulcata Orbigny, Voy. Am. Mer., Moll., p. 584, 1846.

Lucina (Divaricella) quadrisulcata, Dall, Bull. 37, U. S. Nat. Mus., p. 50, 1889.

Divaricella quadrisulcata, Dall, Trans. Wagner Inst. Sci., vol. 3, pt. 6, p. 1389, pl. 51, fig. 1, 1903.

Valves are abundant and some entire animals have been collected at Beaufort. This species should not be confused with *D. dentata* Wood, which the writer has not found at Beaufort.

April, 1912.

THE GLOOMY SCALE, AN IMPORTANT ENEMY OF SHADE TREES IN NORTH CAROLINA.

By Z. P. Metcalf.

The gloomy scale is the most important insect enemy of shade trees in North Carolina. We are led to make this statement for two reasons: First, because it increases far more rapidly than any other insect attacking shade trees, and in the second place it is all but confined to the maples which have been so largely used for shade purposes along the streets of our cities and towns. The gloomy scale is rather closely related to the famous San Jose scale, which is so destructive to our fruit trees. Unlike the San Jose scale it is a native insect. We are led to believe this because the gloomy scale is very heavily parasitized, indicating that it has been established in this country for a long period of time. Then the fact that the scale has been found on a willow along a stream in Lincoln County is another very strong indication of its nativity.

The gloomy scale differs from the San Jose scale in another very vital respect, and that is that it is very much more difficult to control. We believe that this is due to the fact that the gloomy scale lives over the winter as a mature insect, while the San Jose scale lives over the winter as a half grown young. The latter condition enables us to apply very caustic insecticides at a time when the insect is weakest, and at the same time the tree is in a dormant condition so that it is not injured in the least. Then, too, the dorsal scale of the gloomy scale is much thicker and more closely applied to the ventral scale than is the case with the San Jose scale, so that the gloomy scale is especially well protected against any contact insecticide.

These facts forced themselves upon our attention soon after we commenced experiments for the control of this insect four years ago. We soon discovered that the remedies usually recommended for the San Jose scale would be of little or no use against this insect. As a matter of fact the mortality of the scale on some unsprayed trees was less than that of some trees

sprayed with the ordinary lime-sulphur, due perhaps to the fungicidal action of the lime-sulphur killing out the winter form of the red headed fungus, a rather common fungus disease of this insect.

The following winter we tried an extensive series of experiments with all of the manufactured insecticides at our command. These insecticides may be divided roughly into two classes,—the lime-sulphurs and the soluable oils. The lime-sulphurs are highly concentrated mixtures of various compounds of lime and sulphur, which are diluted with water to make mixtures of various strengths for different plants and for different seasons of the year. The soluable oils are essentially the heavier oils of the petroleum series together with a vegetable oil. When mixed with water they make a beautiful emulsion that may be used for spraying with perfect safety. The very day that the mixtures were applied it was evident that the lime-sulphurs would not be as effective as the soluable oils. The former dried on the bark in a very short time, while the latter remained moist for several hours. Thus the soluable oils were enabled to creep in around and under the thick closely-applied dorsal scale and suffocate the insect. While the lime-sulphurs were not able to penetrate the thick dorsal scale, and they dried so quickly that they could not creep under, so that they killed very few insects.

Examinations of the sprayed trees every three or four months until last fall showed that all of the soluable oils had been effective, killing at least 95 per cent. of the scale, while none of the lime-sulphurs had killed over 75 per cent. This represents the difference between an effective and a non-effective spray mixture.

Another point that has been brought out in the course of our investigations is the fact that the soft maples, red and silver, are injured more by this insect than the hard maples like the sugar and Norway. Careful inspection usually shows as high as 90 per cent of the soft maples infested, whereas it is very unusual to find as high as one per cent. of the hard maples infested. In this connection the following host plant list shows

what trees we may reasonably expect to suffer from the attacks of this insect, although it is probable that not all of the trees given will be seriously troubled.

Apple, (Pyrus malus L.) Several young trees growing under the overhanging branches of badly infested red maples found slightly infested.

Red Maple. (Acer rubrum L.) Generally infested.

Silver Maple. (Acer saccharinum L.) Uniformly and badly infested.

Sugar Maple. (Acer saccharum Marsh.) A few scattering individuals found infested, mostly very slightly.

Box Elder. (Acer negundo L.) A few infested.

Buckeye.. (Æsculus glabra Willd.) Slightly infested.

Japanese Chestnut. (Castanea sativa.) Badly infested .

Sycamore. (Platanus occidentalis L.) Slightly infested.

Water Oak. (Quercus nigra L.) A single tree slightly infested.

White Oak. (Quercus alba L.) A few trees slightly infested.

Iron-wood. (Carpinus caroliniana Walt.) A single badly infested tree.

Willow. (Salix sp.) A small badly infested tree found along a stream in Lincoln County.

Cottonwood. (Populus deltoidea Marsh.) Slightly infested tree.

American Elm. (Ulmus americana L.) Slightly infested.

Mulberry.. (Morus rubra L.) Badly infested.

The complete life history of this insect is yet to be worked out, and it is our intention to work this out this summer. We have determined, however, that the females give birth to living young, the first young from overwintering adults being born about the 10th of May. These young molt twice and reach maturity in summer and then give birth to living young. The exact number of generations each year is not known. Neither is the male insect known save for a brief description of two "male" dorsal scales given by Comstock in the original description of this insect. Comstock states that the insects beneath these scales were dead and much shrivelled. Strange to say,

we have never discovered any males, although we have inspected hundreds of trees, most of which were very badly infested, and certainly if males occurred in anyways normal proportions we would have discovered them. At other times we have examined and counted hundreds of scales on selected twigs, and found them all females. Of course parthenogenesis is a possibility, but it does not occur normally in nearly related species; and that leads us to believe that it does not occur here. Although we are almost forced to believe that fertilization, if it occurs at all, occurs in only one generation out of the several generations each year.

CAPTURE OF RALEIGH BY THE WHARF RAT.

By C. S. Brimley.

Three species of rats are commonly known as house rats; these are the Black Rat (Mus rattus), the Brown Rat or Wharf Rat (Mus norvegicus), and the Roof Rat (Mus alexandrinus). Of these, the black rat, formerly the common house rat of Europe, was introduced by the earliest settlers into North America, and in both countries has been practically exterminated by the wharf rat, a late comer. The roof rat, an inhabitant of the Mediterranean regions, has been introduced into the Southern States, as well as into most warm countries, and appears to hold its own against the wharf rat better than the black rat, which it resembles in all but color. In the tropics, however, all three species exist side by side.

In characteristics the three differ as follows: the black rat is sooty black above, somewhat lighter below, and the tail is usually longer than the head and body; the roof rat is brownish gray above, yellowish white below, and has the tail also longer than the head and body; the wharf rat is browner than the roof rat above, and much less white below, (the white being more ashy), while the tail is usually decidedly shorter than the head and body. It is also a considerably heavier animal than the two others. An extra large roof rat will measure 17 inches in total length, of which about 9½ inches would be tail, while an average wharf rat of the same total length would have the tail only about 7 inches, or less.

Up to 1909 the only house rats I had seen in Raleigh were the roof rats, but in that year a wharf rat was brought up to the State Museum some time late in March, the first I had seen since I left England in 1880. During the next year I occasionally saw a dead one that had been thrown on the street, but during 1911 they leaped into prominence. In that year the old cotton platform near the Seaboard freight depot was torn up, and it was the general opinion that multitudes of rats that had been dwelling beneath were then scattered abroad. At any

rate, complaints began to come in to the newspapers about a strange kind of rat that was overrunning Raleigh, and slaughtering young chickens *ad libitum,* and most wonderful stories became current about them. They were as big as cats; large ones weighed three pounds; whenever a hen and chickens were placed in a rat-proof coop resting on the ground, the rats carefully surveyed the coop, and then dug tunnels underneath it, always coming up exactly underneath the old hen, and killing all her chickens without ever showing themselves. Wild as these stories were, they had a foundation in fact, this species being a most inveterate destroyer of small chickens. One of the neighbors, for instance, only a few days ago left a chicken coop open one night and the rats got no less than twenty-six of the thirty chickens in the coop.

They reached my vicinity, a mile from the Seaboard depot, last August, and I have been catching specimens off and on ever since. So far I have not lost any chickens by them, but there is no doubt they are a most serious factor in chicken raising in Raleigh at present.

In habits they are strongly inclined to burrow, while the other two species are climbers, a roof rat when disturbed preferring to seek safety upwards, a wharf rat downwards. The largest specimen I have weighed did not exceed a pound, and several other big ones only reached 14 ounces.

Why they have not overrun Raleigh before it is hard to say, as they are known to have been at Beaufort as far off as 1870 (Coues), and at Newbern in 1885 (H. H. Brimley), while they have been doubtless plentiful at Norfolk and Baltimore ever since Raleigh has been in existence, and specimens have almost certainly been brought in on freight cars every year. We hear that they overran Kinston in a similar manner some years ago.

So far as my premises were concerned, the roof rats had apparently left before the wharf rats came in. It is known however that the roof rat interbreeds with the black rat, and it is claimed that it also does with the wharf rat. However that may be, I have caught several specimens since last fall that were ap-

parently wharf rats, but had tails longer than the head and body as in the roof rat.

Whether the wharf rat will continue to be the house rat of Raleigh in future, or whether local conditions which must certainly have been favorable to the roof rat in the past, will enable the latter species to regain its hold on the town again and drive the wharf rat out, I do not know, but my hopes are for the roof rats' success and my expectations are against it.

RALEIGH, N. C.

VIABLE BERMUDA GRASS SEED PRODUCED IN THE LOCALITY OF RALEIGH, N. C.

By O. I. Tillman.

Cynodon Dactylon (L.) Pers. (*Capriola* Ktze.) Bermuda grass, also known as Wire grass, Bahama grass, Indian couch grass, Scotch grass, and Dog's-tooth grass, is of great economic value throughout the Southern states and is also a noxious pest in certain instances as the very qualities which make it valuable also render it objectionable. It is supposed that this grass will not develop germinable seed in the United States except in the arid Southwest, but it was found that in the vicinity of Raleigh, N. C., this grass produced such seed.

September 8, 1910, flowering stalks were gathered from a grass plot along the city streets. The glumes were stript from these and it was found that 76 per cent. were empty and that there were 24 per cent of pure seed which germinated 82 per cent. Another sample was collected October 11, 1910, along the roadside, a few miles from Raleigh, which was found to produce 4 per cent pure seed, which germinated 60 per cent. The seeds of both samples were kept until June of the following spring before being tested. The tests were made in a standard germinating chamber at an alternating temperature of 20-35 degrees C. The seeds were placed on top of moist blotting paper. The sprouts were strong and some were grown in the laboratory into good-sized plantlets.

Two samples of Bermuda grass seed from the trade, retailing at $1.25 per pound, were tested under the same conditions as the locally grown seed and germinated 27 per cent. and 17 per cent. respectively. This is a striking comparison of the superior germinating value of the locally produced seed and that of the trade, at least in this instance.

Since it has been found that Bermuda grass produces seed of so high a germination in a locality where it was not supposed to produce seed, it might be well if this fact were given consideration both in the cultivation and eradication of the grass.

State Department of Agriculture, Raleigh, N. C.

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VOLUME XXVIII DECEMBER, 1912 No. 3

MALARIAL PIGMENT (HEMATIN) AS A FACTOR IN THE PRODUCTION OF THE MALARIAL PAROXYSM.*

By Wade H. Brown, M. D.

It is remarkable that, from the enormous amount of investigation that has centered about the malarial parasite and its relation to malarial fevers, there has come no clear exposition of the mode of production of the various phenomena of the malarial paroxysm. It is true that these phenomena have been ascribed to the presence in the circulation of some toxic substance, or substances, elaborated by the malarial parasite, and that the blood at the time of the segmentation of the parasite has been shown to possess toxic properties. Still, as far as I know, the nature of these toxic agents remains unknown, as no one has clearly demonstrated the presence of any definite substance, which, when introduced into the circulation, could reproduce the symptom complex of the malarial paroxysm. The observations embodied in this report are offered, therefore, with the hope of shedding some light upon the question.

In the course of some work on hematin metabolism, it was noted that a rabbit that had received an intravenous injection of alkaline hematin developed a very pronounced shaking chill, strikingly like that of malaria. As the author has attempted to show in a previous paper,[1] the pigment elaborated from the hemoglobin of the red blood corpuscle by the malarial parasite

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The first seven experiments of this investigation were done in the Pathological Laboratory of the University of Wisconsin, Madison, Wis.

[1] W. H. Brown, *Jour. Exper. Med.,* 1911, xiii, 290.

and liberated into the circulation of the host at the time of segmentation of the parasite is undoubtedly hematin. It at once appeared possible, therefore, that we might find in this substance one of the hypothetical toxins operative in malaria. The investigation of this question now embraces a series of ninety observations upon the effect of the intravenous injection of alkaline hematin, eighteen rabbits having been used for test purposes.

TECHNIQUE.

Materials Used and Their Preparation.—The hematin used was derived from three sources, rabbit blood, dog blood, and ox blood, but in all cases it was prepared by the Schalfijew process. The solutions for injection were made in 0.85 per cent. salt solution containing 1.5 or 2 per cent. bicarbonate of sodium. The strength of the hematin employed has varied from 1.5 to 5 milligrams per cubic centimeter. The hematin was added to the sterile solvent and heated to 100° C. for five to ten minutes, and was then allowed to stand for twelve to twenty-four hours, when it was again heated and, while still hot, filtered into sterile flasks. The subsequent treatment of these solutions has varied somewhat. Solutions prepared thus, and again heated to 100° C. for five to ten minutes have apparently remained sterile. In a few instances, however, the filtered solution has been autoclaved to insure sterility.

It has been found extremely difficult to prepare hematin solutions of absolutely uniform character. With a given preparation of hematin and with the same technique in the preparation of the solutions, two distinct types of solution may be obtained: one, a perfectly clear, deeply colored solution that even under the microscope shows very few particles of pigment suspension, and on standing shows no precipitation in the flask; the other, a turbid solution that appears chocolate brown in thin layers and under the microscope shows myriads of pigmented particles and droplets floating in an only faintly colored fluid. Much of this pigment is precipitated on allowing the solution to stand. This latter "colloidal" type of solution or suspension, manifests all the optical properties of

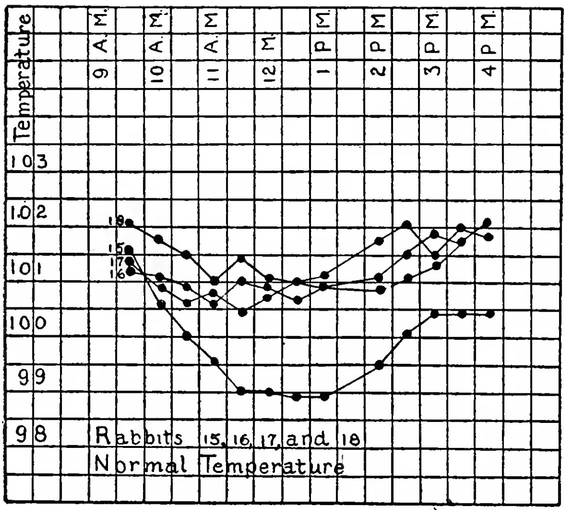
an alkaline hematin solution and the suspended pigment readily passes through Schleicher and Schüll filter paper No. 597 which has been used as the routine filter. With different preparations of hematin these variations in solubility are continually appearing. Reference is made to this feature of the hematin solution to indicate the difficulty in maintaining absolutely uniform experimental conditions and accurate dosage.

Experimental Procedure.— Briefly, the experiments have been conducted according to the following plan: The animals were accustomed to laboratory surroundings by being kept in cages from one to two days before any observations were made. The normal temperature curve of each animal was then established by rectal temperature, taken every half hour from 8 or 9 A. M. until 3 or 4 P. M., the time to be covered by subsequent experiments. As it seemed probable that the sodium bicarbonate salt solution used as the solvent for hematin might produce some toxic manifestations when injected intravenously, the action of this solution was determined in a number of instances, usually in such doses as were subsequently to be administered with the hematin. While these control tests were usually made prior to the injection of hematin, some such tests followed the administration of hematin. The animals were next given intravenous injections of alkaline hematin at 8 or 9 A. M., and the resulting phenomena were noted, the temperature being taken as previously, although fifteen-minute observations were frequently made.

Dose of Hematin.—It is evident that the question of dosage in such a series of experiments is one of prime importance. To carry out the object of these experiments it is quite essential that the dose of hematin employed be somewhat comparable to that liberated into the human circulation at the time of segmentation of a generation of parasites. While there is no evidence to show that all the hemoglobin of the infected red corpuscles is decomposed to form hematin, if we may assume that such is the case, and, further, that a 1 to 5 per cent. infection of red blood corpuscles is not uncommon, we have sufficient data upon which to base a calculation of the approx-

imate amount of hematin liberated into the human host with the segmentation of a given generation of parasites. Basing our calculations on the presence of 8.5 grams of hemoglobin per kilo of body weight, and 4.47 per cent. of hematin in hemoglobin,[2] we find that in a 1 per cent. infection of the red blood corpuscles approximately 3.7 milligrams of hematin per kilo of body weight would be liberated. In my experiments the dosage has varied from 1.3 milligrams to 28 milligrams per kilo of body weight, given in single or in divided doses, corresponding roughly to an infection of 0.3 to 7.5 per cent. of the red blood corpuscles.

Normal Temperature of the Rabbit.—In undertaking an investigation which must necessarily deal so largely with variations in the temperature of the experimental animal, it is im-



TEXT-FIG. I. Normal temperature of four rabbits during the period of the experiments.

perative that the basis of comparison between normal and abnormal fluctuations of temperature be as free from objection as possible. Unfortunately, the temperature of different rabbits

[2] Olof Hammarsten, A Text Book of Physiological Chemistry, translated by Mandel, New York, 1901, p. 139. These figures are probably high.

varies widely, even when kept under exactly the same conditions. In apparently normal animals I have found the individual extremes between 98° and 103° F. Likewise, the fluctuations of temperature in a given animal may be quite considerable, but usually follow a fairly definite course.

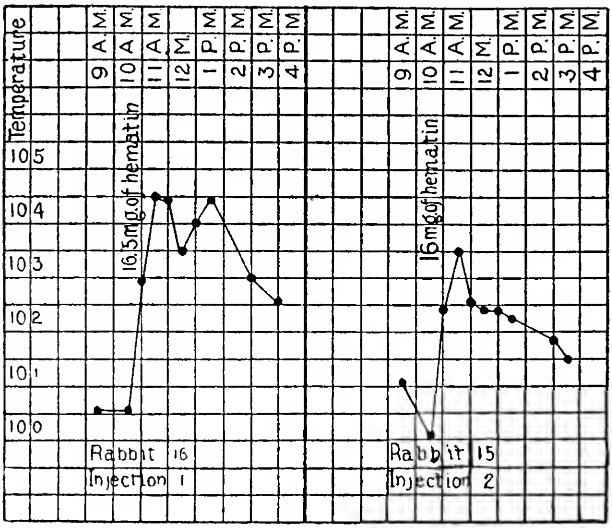
The course and fluctuations of temperature of the normal rabbit under experimental conditions, as well as the individual difference in temperatures, are shown in text-figure 1. This chart shows the normal temperatures recorded for rabbits 15, 16, 17, and 18. The first three animals were from the same litter, about three-quarters grown, and weighed 1,600 to 1,700 grams. Number 18 was full grown and weighed 1,840 grams. All the records were taken at the same time and all conditions were as nearly alike as possible. While three of these curves coincide closely, the fourth shows an extremely low and irregular curve of temperature. It should be noted that the temperature in all instances has a downward trend during the morning hours, and does not show an upward tendency until about noon, when there is a gradual rise, which ultimately reaches as high as the temperature at the first observation or even higher. This temperature curve has been fairly constant in my entire series of experiments.

Effect of Hematin upon Temperature.—If, for purposes of comparison, we adopt the classical division of the malarial paroxysm into a cold stage, a hot stage, and a stage of sweating, with the concomitant symptoms belonging to each, certain of these manifestations are capable of accurate measurements in an experimental animal, while others may be determined with a fair degree of accuracy by close observations, and still others are wholly indeterminable. Of prime importance among these phenomena of the malarial paroxysm is the question of fever.

In estimating the temperature effects, in all instances at least three facts are to be taken into consideration: the nature of the effect, the degree of the effect, and the duration of the effect. While it has been possible to assemble much of the data concerning the effects of hematin upon the temperature in an appended table which shows the abbreviated protocols of the

entire series of experiments, it must be fully appreciated that such tabulations of statistics are wholly inadequate to present many features of the experiments that are equally as important as those thus presented, and attention will be especially directed to such features. Further, as can be seen from these tables, it has been the object of the author to study effects in individual animals with a variety of doses, as occasion suggested, rather than to mould all the experiments to a single type or plan, for it became evident early in this investigation that individual peculiarities of the animals played a prominent rôle in the results obtained.

Without exception, every dose of hematin administered has elicited a definite temperature response. With but three exceptions, this response has been characterized by a sharp rise in temperature, reaching the fastigium in about an hour and a

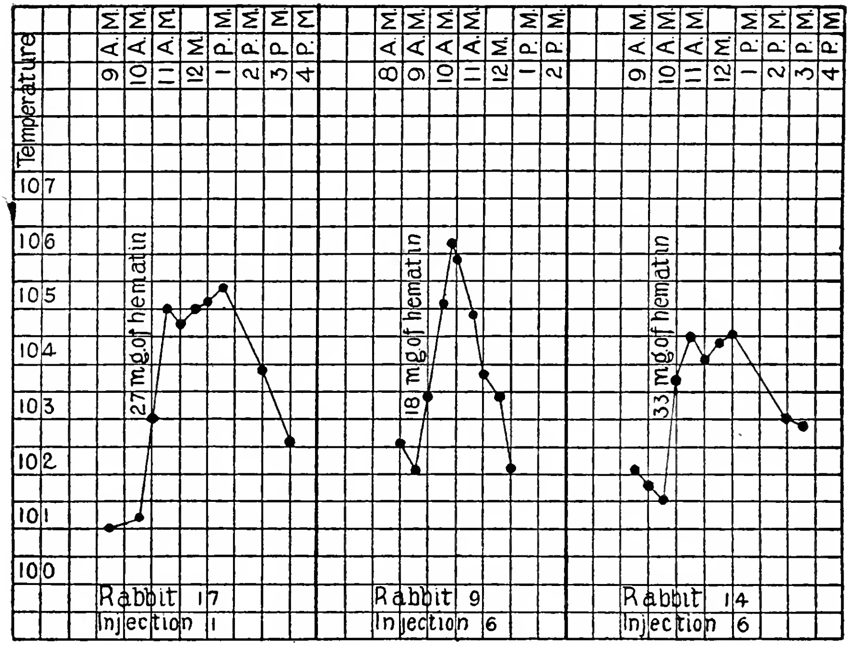


TEXT-FIG. 2. The usual types of temperature curve following injections of hematin.

quarter. The further course was somewhat variable, although in most cases with a dose of 15 milligrams, or less, per kilo, there was a rather sharp fall of temperature for thirty minutes

to one hour, followed by a secondary rise of variable extent and duration or a very gradual decline requiring several hours to reach normal again. Two such temperature curves are shown in text-figure 2.

These curves are subject to innumerable variations depending upon the dose, the stage of the experiment, and upon the individual peculiarities of animals. Some of the more important variations are an accentuation and prolongation of the secondary rise, usually shown with initial and large doses, or a defervesence that is almost as sharp as the rise in temperature. A third variation, which includes the three exceptions previously noted, is met with in instances of marked intoxication and is characterized by an initial drop in temperature with a subsequent rise. All three of these modifications are illustrated in text-figure 3.



TEXT-FIG. 3. Variations in the temperature curve following large doses of hematin or repeated injections of hematin.

The extent of the temperature elevation is, within certain limits, proportional to the amount of hematin injected. The temperature effect, being very slight with small doses, increases with the dose, until we begin to obtain signs of an over-intoxication when the elevation may be much less than with smaller doses, the optimum dose usually being between 10 and 15 milligrams per kilo of body weight. The elevation of temperature obtained with such optimum doses is from 3° to 3.5° F., and it is exceptional that a greater rise is reached. Occasionally, however, the temperature may rise 4° F. or even higher in highly susceptible animals. The greatest elevation recorded in my series of experiments was 4.9° F. in animal No. 9, with a dose of 18 milligrams of hematin per kilo.

In well-marked reactions, the temperature usually returns to within the normal range in the course of three to five hours. With large or initial injections of hematin, the period of elevated temperature is more prolonged than under other circumstances and seldom reaches normal in less than four hours, occasionally requiring as much as six hours. Exceptionally, the return to normal may be rapid (text-figure 3).

The method of administration also plays an important part in the results. A given dose of hematin injected in two or three fractional doses at intervals of fifteen to thirty minutes produces a much more marked elevation of temperature than when given at a single injection, an effect that is well shown in rabbit 13. This is particularly true of the smaller, or optimum doses, while with larger doses the increased potency may be manifested by a slowing of the rise of temperature, a cessation of the rise, or even a fall upon the injection of the second fraction, as illustrated in rabbit 12.

Neither the source of the hematin nor the type of solution seems to play an important part in the results that I have obtained. That is, there has been but slight difference between the action of rabbit, dog, or ox hematin, or between the action of the perfectly clear hematin solution and that containing much finely divided hematin in suspension.

However, a few tests seem to indicate that solutions of hem-

atin gradually lose their pyrogenic properties with age or when subjected to high and prolonged temperature. This apparent decrease may be seen by comparing the results obtained in rabbit 7, injection 3, and rabbits 8, 10, and 11. Further, it can readily be imagined that all animals will not be found equally susceptible to the toxic action of hematin. A few will exhibit a marked sensitiveness and a few will be found extremely resistant, the optimum dose in the one producing but slight effect in the other. This variation in susceptibility was strikingly illustrated by animals 13 and 14 which were under observation at the same time. Rabbit 13 was a typically resistant animal, and rabbit 14 was highly sensitive.

Effect of Sodium Bicarbonate Salt Solution upon the Temperature.—Animals injected with the bicarbonate salt solution alone, for purposes of control, almost invariably showed an elevation of temperature in proportion to the size of the dose, and about one-third to one-half the elevation produced with an equal amount of hematin solution, depending somewhat upon the concentration of the hematin in the solution. With small doses of the control medium, the fluctuations of temperature were usually within what might be termed the normal range and were such that it is difficult to say whether they are more than incidental to the process of injection. Large doses may produce a rise in temperature corresponding approximately to the over-intoxicating effect of large doses of hematin. In such instances, however, other features of the clinical picture will distinguish sharply between the two cases. In all instances, therefore, there were distinct differences between the action of the sodium bicarbonate salt solution and the action of the hematin solution, such that there can be no question as to the part played by the hematin in these experiments.

Other Phenomena of the Hematin Paroxysm.—Apart from the elevation of temperature in the experimental animal, the paroxysm of hematin intoxication presents other features which are of equal importance and show a strong resemblance to corresponding phenomena of the malarial paroxysm. For the first fifteen to twenty minutes following the injection of

hematin, the rabbit usually manifests a slight degree of restlessness, then crouches in a corner of the cage. In the second stage of the paroxysm the vessels of the ears contract giving to the shaved ears a pale and cyanotic hue, while at the same time the ears become decidedly cold. In pronounced cases the surface temperature (temperature of the ears) may be more than 30° F. below the rectal temperature. The lowest temperature recorded in this series of experiments was 63.5° F. with a room temperature of 62.5° F., and a rectal temperature of 105° F. During this stage the animal's ears usually lie on its back, and the hair tends to become erect, presenting the picture of an animal that is cold. Meanwhile, the rabbit shows convulsive tremors or shivering, but rarely any continued or pronounced shaking. This stage of chill lasts from forty-five minutes to one hour, and is terminated rather abruptly by a dilation of the superficial vessels, the ears rapidly becoming flushed and hot. The animal now moves about the cage or stretches out and remains quiet. Further than this, the third or hot stage of the paroxysm possesses no especial symptoms and its limit can be fixed only by the course of the temperature, which may remain well above normal for several hours, or sink to normal within an hour. During the third stage and the latter part of the second stage of the paroxysm the animal shows a pronounced thirst which is undoubtedly referable to the febrile condition.

The most striking and at the same time the most constant of all these symptoms are the contraction and dilatation of the superficial vessels associated with the corresponding lowering and elevation of the surface temperature.

The contrast between the symptoms of the animal injected with hematin and those of control animals is quite as sharp as in the instance of the temperatures. With doses of hematin sufficiently large to produce pronounced symptoms of the type described, corresponding doses of sodium bicarbonate salt solution produce practically no recognizable effect. There may be a suggestive or very transient change in the surface vessels and the temperature, but nothing that is definite or constant. When,

however, larger doses, *e. g.*, ten cubic centimeters per kilo, are given, phenomena simulating the picture of hematin intoxication may be elicited, but the changes are not so definite or constant.

If now we correlate these symptoms with the temperature curve, we find that the elevation of temperature during the first stage is slight, and that the second stage of the paroxysm corresponds closely with the period of rising temperature, the initial drop coinciding sharply with the vascular dilatation and flushing of the ears and the elevation of the surface temperature. The third or hot stage, as previously noted, corresponds to the duration of the temperature above normal.

As in the case of the temperature, all other phenomena of hematin intoxication seem to be exaggerated when a given dose of hematin is divided into several fractional doses, the cycle of phenomena following closely consequent changes in the temperature curve.

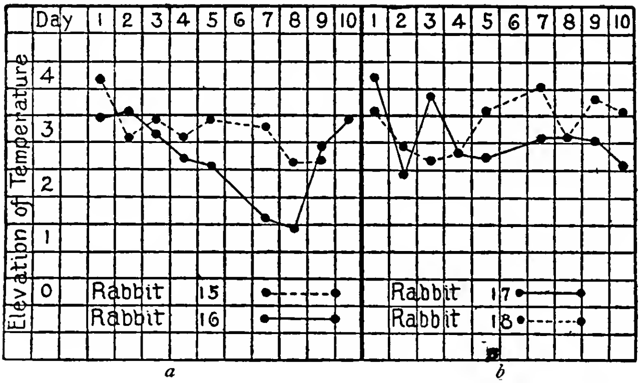
It must be pointed out, however, that the prominence of these paroxysmal phenomena and the degree of elevation of the temperature are by no means always parallel. The toxic paroxysmal phenomena may be present to a high degree in an animal that shows only a slight elevation of temperature, and in most instances such a condition is to be regarded as evidence of over-intoxication.

Acquired Resistance.—Early in the course of these experiments it became evident that repeated injections of a given dose of hematin in the same animal did not give uniform results. The results, however, were of such a nature as to suggest that the animal acquired a certain degree of tolerance which, in turn, might be broken when the intoxication was pushed sufficiently. To determine this point the following experiment was carried out.

Experiment.—Four rabbits, weighing respectively 1,600, 1,650, 1,790, and 1,840 grams, were injected on ten successive days with a solution of ox hematin containing 5 mg. of hematin to 1 c.c. The first two animals received 10 mg. of hematin per kilo of body weight, and the other two received 15 mg. per kilo. Rectal temperatures were recorded every half hour.

The results are shown in text-figure 4. In *a* is shown the

differences of elevation of temperature on successive days of the two animals receiving ten milligrams per kilo, and in *b* those receiving fifteen milligrams per kilo.



TEXT-FIG. 4. Variations in the elevation of the temperature with repeated injections of a given does of hematin.

While the curve of temperature reaction in each case is extremely irregular, it is in general characterized by a tendency towards a decrease, which in the instance of animals 16 and 17 persists throughout the experiment. With animals 15 and 18, however, a second phase of increased reaction is developed. These animals also exhibited the most marked symptomatic effects throughout the experiment. If the temperature curve alone be considered, it is certain that the tendency is toward a decreasing response to successive injections of hematin, and this I have found to be true in other experiments. If we take into consideration other evidence of intoxication, however, as in animals 15 and 18, this decrease seems referable not so much to a tolerance as to over-intoxication. Again, as these symptoms of intoxication decrease and the fluctuations of temperature increase correspondingly, there may be developed a certain degree of tolerance. On the other hand, as shown in animals 16 and 17, there may be an increasing resistance to the hematin from the start as the toxic symptoms as well as the temperature decrease proportionally.

This subject of acquired tolerance has been taken up largely to emphasize the importance to be attached to results obtained from properly adjusted initial doses of hematin, but also to explain the apparent discrepancies in the results from any series of hematin injections. It is the initial injection, with but few exceptions, that gives the maximum temperature reaction obtainable with a given dose of hematin until the series of injections has been extended to such a degree as to permit of the acquirement of a tolerance in highly susceptible animals or to cause a break in the early acquired tolerance of more resistant animals. When such conditions supervene, the temperature reaction may again increase and show an even greater response than with the initial injection (table I, animals 9 and 18).

SUMMARY.

The paroxysm of hematin intoxication in the rabbit undoubtedly presents many features of striking similarity to the paroxysm of human malaria; still one must hesitate to apply such results unreservedly in an attempt to identify the causative agent of the malarial paroxysm. When, in addition to the character of the paroxysm, we consider the sequence of events in the two instances, the analogy becomes so close that it seems impossible to regard the matter as a mere coincidence. The injection of hematin, especially in fractional doses, is in a measure comparable to the liberation of hematin into the human circulation by the malarial parasite. In these experiments, both solution and finely divided suspensions of hematin have been found equally effective in eliciting the phenomena of the paroxysm, and while it seems possible that a portion of the malarial pigment might be dissolved in the alkaline human serum, such an assumption is probably not essential.

It might be objected that the toxic action of foreign hematin thus injected into the circulation would probably be greater than that of hematin derived from an animal's own blood, but as far as I have been able to determine, this objection does not seem valid, as rabbit hematin, dog hematin, and ox hematin

TABLE I.—*Summary of Experimental Data.*

No. of Animal; Weight in Kilos.	Date of Injection.	Sodium Bicarbonate Salt Solution in c.c.	Hematin Solution in c.c.	Hematin per Kilo of Body Weight in mg.	Temperature (F.) at Time of Injection.	Elevation of Temperature with Sodium Bicarbonate Salt Solution.	Elevation of Temperature with Hematin.	Time in Hours to Fastigium.	Temperature 3 hours after Injection.	REMARKS.
No. 1. Weight, 2.49.	Jan. 27, 1911	5.0			102.3	1.1		2	102.6	Rabbit hematin in all injections.
	Jan. 30, 1911		5.0	3.0	102.5		2.5	3	105.0	Highest temperature on secondary rise.
	Jan. 31, 1911		10.0	6.0	101.8		2.2	1½	102.8	
	Feb. 1, 1911		5.0	3.0	103.0		1.4	1½	103.0	
	Feb. 2, 1911		20.0	12.0	103.0		0.0		96.4	In two doses, 5 minutes apart. Died 3 hours after injection.
No. 2. Weight, 2.78.	Feb. 1, 1911	10.0			102.8	1.8		2½	104.3	
	Feb. 2, 1911	10.0			102.2	1.8		1½	103.0	Rabbit hematin.
	Feb. 3, 1911	23.0			102.1	2.5		1	102.8	
	Feb. 7, 1911		5.0	2.6	102.9		3.1	1¼	106.0	Initial rise to 106 degrees with fall to 105.3 degrees F. and second rise.
	Feb. 8, 1911		2.5	1.3	102.6		1.2	1	103.0	
	Feb. 9, 1911		7.5	3.9	102.5		2.6	1¼	104.0	
	Feb. 11, 1911		7.5	3.9	102.4		3.0	1¼	103.9	
	Feb. 15, 1911		15.0	7.8	102.3		4.0	1¼	106.1	
	Feb. 16, 1911		20.0	10.4	102.8		3.3	1¼	104.9	
No. 3. Weight, 2.9.	Feb. 8, 1911		2.5		102.7					2.5 c.c. thick suspension of hematin in 0.85 per cent. salt solution. Died instantly.
No. 4. Weight, 2.65.	Feb. 8, 1911	10.0			102.6	1.4		1½	102.8	
	Feb. 9, 1911		7.5	4.2	102.2		2.6	1¼	104.6	Rabbit hematin.
	Feb. 11, 1911		7.5	4.2	102.3		2.8	1¼	103.8	
	Feb. 15, 1911		10.0	5.7	102.4		2.5	1¼	104.8	

No. of Animal: Weight in Kilos.	Date of Injection.	Sodium Bicarbonate Salt Solution in c.c.	Hematin Solution in c.c.	Hematin per Kilo of Body Weight in mg.	Temperature (F.) at Time of Injection.	Elevation of Temperature with Sodium Bicarbonate Salt Solution.	Elevation of Temperature with Hematin.	Time in Hours to Fastigium.	Temperature 3 hours after Injection.	REMARKS.
No. 4. Weight, 2.65.	Feb. 16, 1911		15.0	8.4	101.6		2.1	3	103.7	Temperature dropped to 100.7 degrees F., then rose very slowly.
No. 5. Weight, 2.85.	May 1, 1911	7.0			101.8	1.3		1½	102.2	
	May 2, 1911		7.0	5.0	102.0		3.6	1½	105.0	Dog hematin.
	May 3, 1911		7.0	5.0	102.3		3.2	1¼	104.7	
No. 6. Weight, 2.57.	May 1, 1911	8.0			102.4	1.6		1½	103.0	
	May 2, 1911	10.0			101.8	1.2		1½	102.2	Other manifestations very slight.
	May 3, 1911	15.0			102.0	1.7		1¼	103.3	
	May 4, 1911	20.0			102.1	2.1		1½	103.5	
No. 7. Weight, 2.53.	May 1, 1911	8.0			101.6	1.5		2	102.0	
	May 2, 1911		8.0	4.7	101.2		3.7	1¼	104.0	Rabbit hematin.
	May 3, 1911		8.0	6.3	101.3		3.1	1¼	103.6	Dog hematin.
No. 8. Weight, 1.85.	Oct. 18, 1911	6.0			102.1	1.4		1½	102.8	Hematin solution 5 mos. old, same as that used in No. 7, injection 3.
	Oct. 20, 1911		6.0	10.0	102.3		1.8	1½	103.0	
No. 9. Weight, 2.05.	Oct. 20, 1911	12.0			102.5	2.0		1½	102.7	
	Oct. 23, 1911		12.0	12.0	102.3		3.3	1	103.4	Oxhematin in all injections
	Oct. 25, 1911		12.0	12.0	102.5		2.7	1¼	102.7	
	Oct. 26, 1911		12.0	12.0	103.6		2.0	¾	103.0	An afternoon experiment. Temperature back to 103.6 degrees in 1½ hours.
	Oct. 27, 1911		12.0	12.0	102.1		3.7	1	103.1	
	Nov. 1, 1911		12.0	12.0	102.1		4.1	1¼	103.4	

No. of Animal; Weight in Kilos.	Date of Injection.	Sodium Bicarbonate Salt Solution in c.c.	Hematin Solution in c.c.	Hematin per Kilo of Body Weight in mg.	Temperature (F.) at Time of Injection.	Elevation of Temperature with Sodium Bicarbonate Salt Solution.	Elevation of Temperature with Hematin. Time in Hours to	Fastigium.	Temperature 3 hours after Injection.	REMARKS.
No. 9. Weight, 2.05.	Nov. 3, 1911		12.0	12.0	101.8		4.3	1½	——	
	Nov. 6, 1911		18.0	18.0	101.5		4.9	1	103.5	Given in two doses 5 minutes apart.
No. 10. Weight, 1.85.	Oct. 25, 1911		12.0	20.0	102.6		0.8		103.0	Hematin solution 5½ mos. old, same as No 7 injection 3, and No. 8, injection 2.
	Oct. 27, 1911		12.0	20.0	102.2		1.5		102.8	
No. 11. Weight, 2.0.	Oct. 27, 1911		5.0	7.5	102.6		0.6	1	102.5	Hematin solution, same as No. 10.
	Nov. 3, 1911	12.0			101.6	1.3		1½	101.6	
	Nov. 6, 1911	18.0			101.0	2.4		2	102.2	Ox hematin in all other injections.
	Nov. 8, 1911		6.0	6.0	101.4		2.6	1	102.8	
	Nov. 10, 1911		12.0	12.0	100.4		3.0	1¾	102.8	
	Nov. 13, 1911		18.0	18.0	100.3		3.9	3	104.2	
	Nov. 15, 1911		10.0	20.0	100.5		4.5	1½	103.0	
	Nov. 17, 1911		8.0	16.0	100.8		3.2	1¼	103.2	
No. 12. Weight, 2.0.	Nov. 10, 1911		15.0	15.0	101.2		3.2	1½	103.9	Ox hematin.
	Nov. 13, 1911		18.0	18.0	101.3		4.0	1½	105.0	
	Nov. 15, 1911		10.0	20.0	101.0		3.3	1	102.9	
	Nov. 17, 1911		8.0	16.0	101.7		3.1	1¾	104.0	
	Nov. 20, 1911		10.0	20.0	102.5		1.9	1½	103.3	In two doses 30 minutes apart. Initial rise checked by second dose.
	Nov. 22, 1911		5.0	10.0	101.4		3.4	1¼	103.4	
	Nov. 24, 1911		4.0	8.0	101.5		4.2	1¼	104.0	Apparently about optimum dose.
	Nov. 27, 1911		8.0	16.0	101.4		3.0	1½	103.1	

No. of Animal; Weight in Kilos.	Date of Injection.	Sodium Bicarbonate Salt Solution in c.c.	Hematin Solution in c.c.	Hematin per Kilo of Body Weight in mg.	Temperature (F.) at Time of Injection.	Elevation of Temperature with Sodium Bicarbonate Salt Solution.	Elevation of Temperature with Hematin.	Time in Hours to Fastigium.	Temperature 3 hours after Injection.	REMARKS.
No. 13. Weight, 2.15.	Nov. 22, 1911	5.0			102.2	0.4		1	101.8	Ox hematin.
	Nov. 24, 1911		4.3	10.0	102.0		1.5	1	102.2	Single dose.
	Nov. 27, 1911		4.3	10.0	102.2		3.3	1¼	102.5	In 2 doses 30 minutes apart
	Nov. 29, 1911	4.3			102.2	1.4		1¾	102.7	In 2 doses 30 minutes apart
	Dec. 4, 1911	4.3			101.6	1.4		2½	102.8	In 2 doses 30 minutes apart
	Dec. 6, 1911		4.3	10.0	101.8		3.0	1¼	103.6	In 2 doses 30 minutes apart
	Dec. 8, 1911		2.1	5.0	101.7		2.1	1½	102.6	In 2 doses 30 minutes apart
	Dec. 11, 1911		10.0	23.0	101.5		2.9	1¼	103.8	In 2 doses 30 minutes apart
	Dec. 13, 1911		10.0	23.0	102.1		2.6	1	103.0	Single dose.
	Dec. 15, 1911		12.0	28.0	101.5		3.5	1	103.5	Single dose.
	Dec. 18, 1911		12.0	28.0	101.4		4.3	1¼	104.4	Given in 2 doses 30 minutes apart.
No. 14. Weight, 2.25.	Dec. 6, 1911	4.5			100.7	1.9		2¼	102.2	Ox hematin. Given in 2 doses 30 minutes apart.
	Dec. 8, 1911	2.2			100.4	1.6		2	—	Given in 2 doses 30 minutes apart.
	Dec. 11, 1911		2.2	5.0	101.0		3.2	1¾	103.4	Given in 2 doses 30 minutes apart.
	Dec. 13, 1911		3.3	7.5	101.0		3.4	1¾	103.6	Given in 3 doses 30 minutes apart.
	Dec. 15, 1911		4.5	10.0	101.5		2.6	1½	103.0	Given in 2 doses 30 minutes apart. Over-intoxication.
	Dec. 18, 1911		6.6	15.0	101.7		2.8	1½	104.5	Single dose. Over intoxication.

No. of Animal; Weight in Kilos.	Date of Injection.	Sodium Bicarbonate Salt Solution in c.c.	Hematin Solution in c.c.	Hematin per Kilo of Body Weight in mg.	Temperature (F.) at Time of Injection.	Elevation of Temperature with Sodium Bicarbonate Salt Solution.	Elevation of Temperature with Hematin.	Time in Hours to Fastigium.	Temperature 3 hours after Injection.	REMARKS.
No. 15. Weight, 1.6.	Jan. 12, 1912	3.2			100.6	1.5		1½	100.6	
	Jan. 16, 1912		3.2	10.0	99.8		3.2	1½	102.5	Ox hematin.
	Jan. 17, 1912		3.2	10.0	100.1		3.4	1½	102.3	
	Jan. 18, 1912		3.2	10.0	101.0		3.0	1	101.8	
	Jan. 19, 1912		3.2	10.0	101.2		2.5	1	102.6	
	Jan. 20, 1912		3.2	10.0	101.0		2.4	1½	101.9	
	Jan. 21, 1912									Another injection here without a record of temperature.
	Jan. 22, 1912		3.2	10.0	101.6		1.5	1½	102.0	
	Jan. 23, 1912		3.2	10.0	101.5		1.2	2½	102.7	Initial fall in temperature.
	Jan. 24, 1912		3.2	10.0	101.5		2.7	1	103.3	
	Jan. 25, 1912		3.2	10.0	101.8		3.2	1	104.0	
No. 16. Weight, 1.65.	Jan. 12, 1912	3.3			101.1	2.7		1½	102.3	
	Jan. 16, 1912		3.3	10.0	100.6		3.9	1	104.4	Ox hematin.
	Jan. 17, 1912		3.3	10.0	101.8		2.8	1	102.9	
	Jan. 18, 1912		3.3	10.0	102.1		3.1	1	101.8	
	Jan. 19, 1912		3.3	10.0	102.0		2.9	1½	103.3	
	Jan. 20, 1912		3.3	10.0	102.5		3.2	1½	103.0	
	Jan. 21, 1912									Injection here with no record.
	Jan. 22, 1912		3.3	10.0	102.0		3.0	1½	103.1	
	Jan. 23, 1912		3.3	10.0	102.1		2.6	1½	103.0	
	Jan. 24, 1912		3.3	10.0	102.3		2.4	1	—	Leg broken by accident. Discontinued.

No. of Animal; Weight in Kilos.	Date of Injection.	Sodium Bicarbonate Salt Solution in c.c.	Hematin Solution in c.c.	Hematin per Kilo of Body Weight in mg.	Temperature (F.) at Time of Injection.	Elevation of Temperature with Sodium Bicarbonate Salt Solution.	Elevation of Temperature with Hematin.	Time in Hours to Fastigium.	Temperature 3 hours after Injection.	REMARKS.
No. 17. Weight, 1.79.	Jan. 12, 1912	5.4			101.2	2.5		1½	103.2	Ox hematin.
	Jan. 16, 1912		5.4	15.0	101.3		4.0	3	105.3	Temperature reached 105 degrees F. in 1 hour.
	Jan. 17, 1912		5.4	15.0	101.8		2.2	1	102.7	
	Jan. 18, 1912		5.4	15.0	101.5		3.6	1	102.6	
	Jan. 19, 1912		5.4	15.0	102.0		2.6	1½	103.3	
	Jan. 20, 1912		5.4	15.0	102.0		2.6	1½	103.3	
	Jan. 21, 1912									Injection here with no record.
	Jan. 22, 1912		5.4	15.0	102.2		2.8	1½	103.2	
	Jan. 23, 1912		5.4	15.0	102.1		2.9	1½	103.3	
	Jan. 24, 1912		5.4	15.0	102.6		2.8	1	103.3	
	Jan. 25, 1912		5.4	15.0	102.6		2.6	1	103.1	
No. 18. Weight, 1.84.	Jan. 12, 1912	5.5			101.5	2.6		2	103.2	
	Jan. 16, 1912		5.5	15.0	101.6		3.4	3	105.0	Ox hematin.
	Jan. 17, 1912		5.5	15.0	102.0		2.8	1½	103.5	
	Jan. 18, 1912		5.5	15.0	101.9		2.5	1	103.6	
	Jan. 19, 1912		5.5	15.0	102.3		2.6	1½	103.8	
	Jan. 20, 1912		5.5	15.0	101.5		3.4	1½	103.7	
	Jan. 21, 1912									Injection here with no record.
	Jan. 22, 1912		5.5	15.0	101.9		3.8	1	103.4	
	Jan. 23, 1912		5.5	15.0	102.2		2.8	1½	104.7	
	Jan. 24, 1912		5.5	15.0	102.5		3.6	1	103.7	
	Jan. 25, 1912		5.5	15.0	102.7		3.3	1	104.6	

produce in the rabbit effects that are alike in both character and degree.

The dose of hematin remains as the one factor to which it is possible to attach some degree of uncertainty, but even here the author feels that the range of experimental conditions has been kept within the bounds of legitimate analogy with conditions existing in the human subject of malarial infection.

Finally, the most conservative estimate of the value of such experiments points strongly to the fact that we have at least a potentially toxic substance in the pigment hematin as liberated by the malarial parasite into the circulation of the human host.

There is also abundant evidence to show that the action of hematin is not confined to the paroxysmal phenomena of malaria, but that other features of the disease may find their explanation in the action of this pigment. For the present, however, it seems advisable to confine the discussion to this one phase of the question.

CONCLUSIONS.

1. Alkaline hematin in doses commensurate with the amounts of hematin liberated in the human circulation by the segmentation of the malarial parasite, produces, when injected intravenously into the rabbit, a paroxysm which is characterized by a short prodromal stage, a stage of chill and rising temperature, and a hot stage. In their details the phases of this paroxysm are practically identical with the corresponding ones in the paroxysm of human malaria.

2. The phenomena in human beings infected with malaria are, at least in part, directly referable to the toxic action of this malarial pigment.

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THE PAST, PRESENT, AND FUTURE OF THE NAVAL STORES INDUSTRY.*

By Chas. H. Herty.

The limited use of the oleoresinous exudate of pine trees dates back many centuries, but the real beginning of an industry on a large scale is closely associated with the discovery of the vast pine forests which extend along the southeastern and southern coasts of the United States from North Carolina to Texas.

These forests lie chiefly in the coastal plain and in the slightly hilly country between the Piedmont plateau and the coastal plain, a strip varying in width from one hundred to two hundred miles and characterized by a sandy soil, covered for the most part with "wire-grass," this furnishing a beautiful carpet of green in spring and summer, but making a serious fire risk in winter. The longleaf pine readily sheds its lower limbs, especially in close stands, so that the forests are remarkably open and free from that undergrowth, which, in the northwest, leads to such destructive forest fires.

The early settlers in eastern North Carolina began the exploitation of their forests of longleaf pine for the purpose of providing tar and pitch for use in the construction of wooden ships, and gradually extended their operations to the collection of crude turpentine which was shipped to northern cities or England for distillation. The forests covered the entire territory and, as clearings for farms were needed, destructive methods of operation were welcomed and encouraged.

At the same time limited operations were being conducted upon the maritime pine in southwestern France between Bordeaux and Bayonne. To receive the crude turpentine the French made use of a hole dug in the sand at the base of the tree. The oleoresin flowing from the wound on the trunk above was collected in these holes. Necessarily by this method much of the material was wasted and rendered impure.

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AMERICAN METHOD OF COLLECTION.

In North Carolina the method of collection was improved, or thought to be improved, by cutting a large opening, the "box," in the base of the tree. Into this box the crude turpentine flowed and was collected at regular intervals. The conservative character of the men engaged in this industry led to the continuance of this wasteful and destructive method of "boxing" until the very recent past.

Briefly, the method of operating so long in use in the United States is as follows: In the winter the laborers are engaged in cutting "boxes." Each box is then "cornered," a wide chip being removed from each half of the box to provide a surface suitable for directing the flow of crude turpentine to the box. Meanwhile, other laborers are employed in clearing all combustible material from around each tree, "raking." Ground fires are then started to consume the dead wire grass, chips, etc. With the opening of spring "chipping" begins. This consists in scarifying each week the trunk of the tree above the "cornered" surface by means of a "hack," a U shaped steel tool set in a wooden handle. Attached to this handle is a heavy iron weight to give momentum to the free arm swing used in chipping. After four or five weeks the "boxes" average a good filling and the crude turpentine, "dip," is then transferred to buckets by flat, iron paddles, and from the buckets it is collected in barrels conveniently placed in the woods. In the fall, at the end of the chipping season, the hardened oleoresin, which which has gradually collected during the chipping season on the scarified surface of the tree, is removed by scraping, giving thus the name "scrape" to this product, which is sold as "Gum Thus," or distilled. In the following winter the trees are again raked and the grass fired, and in the spring chipping is resumed at the point on the trunk of each tree where it ceased the previous year. This cycle is usually continued from three to four years, although in early days it was often continued ten or twelve years, the scarified surface extending high on the trunks. Necessarily the yield from such high chipping was largely decreased, owing to the increased distance of flow to the receptacle.

In the early days of the North Carolina industry, no effort was made to distill the product, but gradually it became clear that it would be better to separate the crude turpentine into spirits of turpentine and rosin by distillation in the woods. For this purpose iron stills were used at first, but results were unsatisfactory until the introduction of copper stills, which were less liable to crack and could be heated with greater uniformity and better control.

The industry now began to grow rapidly and before many years it was found that the supply of available timber in North Carolina was rapidly decreasing. This led many of the operators to transfer their operations to the virgin forests of the adjoining state of South Carolina, where the same destructive methods were applied by the same men or their descendants. In this way, and for these reasons, the center of the industry has gradually moved southward and then westward as evidenced by the relative prominence of the ports for exports of the products; first Wilmington, N. C., then Charleston, S. C., then Savannah, Ga., and now the latter, together with Jacksonville, Fla., and the gulf ports, Tampa, Fla., Pensacola, Fla., Mobile, Ala., Gulfport, Miss., New Orleans, La., and others.

FRENCH IMPROVEMENTS.

The steady growth of the American industry received a serious check during the Civil War. The consequent scarcity of the products was accompanied by an abnormal increase in their value. This enhanced valuation led Hugues, a Frenchman, to propose a less wasteful method for the French forests than the hole dug in the sand. He proposed as a substitute a clay pot, holding about one pint. The pot was supported on its bottom by a large nail driven into the tree and on one side of its upper rim by a strip of sheet zinc, approximately 2″ x 4″, slightly curved and driven into a correspondingly upwardly inclined cut in the wood. This spout served to direct the oleoresin into the pot. At first his proposition was scoffed at and the peasants amused themselves by breaking the little pots. It is a pitiful

commentary that Hugues died in poverty; but his ideas lived and gradually became adopted in France.

AMERICAN IMPROVEMENTS.

As the knowledge of the new method in France spread to this country, numerous efforts were made to apply similar forms of apparatus to the American system of chipping, but for many years such efforts failed. No less than fifteen patents were issued in the United States on this subject, but no one of them proved a commercial success.

Eleven years ago the writer began a series of field experiments on a small scale in the turpentine forests of South Georgia. One feature of these experiments was the use of a modification of the Hugues system, consisting of two separate metallic gutters, inserted in upwardly inclined cuts in the tree, along which the oleoresin flows. The upper and shorter gutter is separated at its lower end about one inch from the lower gutter and empties into it. The lower gutter extends from two to three inches beyond the center of the angular scarified surface formed in chipping, and serves as a spout to convey the oleoresin to a cup suspended from a nail just below the end of the gutter. These cups are made either of well burned clay or galvanized iron, and have a capacity of one quart.

Attracted by the promising character of these preliminary experiments, the U. S. Bureau of Forestry began a series of field tests of the apparatus on a large scale, the work being under the immediate supervision of the writer. Before the end of the first season of testing it was evident that the apparatus was a practical success, and the results attained, both as to quantity and quality of oleoresin, justified the hope of immediate commercial introduction of the system. But the habits of long years made difficult the adoption of such an innovation. This ultra-conservatism was slowly overcome and the adoption of the new system spread rapidly. Only a few more years will be required to witness the complete replacement of the "box" by the "cup" system in American forests. A detailed account

of these experiments is given in Bulletin No. 40 and Circular No. 34 of the U. S. Bureau of Forestry.

With the main points at issue settled, namely—improved yields both in quantity and quality of the products and preservation of the trees, other forms of apparatus were devised to meet the objections of some of the operators to certain points in the cup and gutter system. Many of these have never proved practical, but some have been introduced on a considerable commercial scale.

The successful outcome of the experiments on the relative yields from the "box" and the "cup" system led the United States Forest Service to further experiments in more conservative treatment of the trees in chipping. Comparative studies were made of the yield from deep and shallow chipping and the latter found to give the greater yield during a period of four years of operation. Other experiments showed that a less rapid rate of ascent of the trunk also gave larger yields, and experiments combining these several modifications of present practices showed a largely increased yield. A final set of experiments pointed clearly the rational way to a perpetuation of the naval stores industry in America. The details of this investigation are given in Bulletin No. 90 of the United States Forest Service.

DISTILLATION.

In the matter of distillation, only slight advances have been made in America. The uniform process consists in the use of a large copper kettle and condensing worm. The charge for a distillation averages nine to ten barrels of crude turpentine. The kettle is heated by free flame and during the distillation a small stream of hot water from the top of the condenser tub is admitted through an opening in the upper part of the kettle, thus facilitating the removal of the volatile oil. The condensed spirits of turpentine and water separate in the receiver, owing to difference in specific gravity, and the lighter spirits of turpentine is transferred to oak barrels, well coated with glue on the inside. No effort is made to redistill this product, and it always comes upon the market contaminated by a small amount

of resin carried over mechanically during distillation. After most of the volatile oil has passed off, the still cap is removed, excess water in the kettle boiled off, and the molten rosin drawn off through a tap in the bottom of the kettle onto a coarse wire filter, then through a second filter of fine mesh wire overlaid with cotton batting. The molten rosin is then dipped into wooden barrels luted with clay and solidifies on cooling. In this condition it is shipped to market.

The usual method of controlling the distillation is by the sound heard at the mouth of the condenser worm. Within the past three years a number of American operators have substituted for this method that of thermometer control with very excellent results.

In France, much more progress has been made in the art of distillation. Among the French distilleries there are three distinct types: first, a system closely resembling the American; second, distillation solely by steam in steam jacketed vessels; and third, a mixed system in which there is direct contact of fire with the kettle during the first stage of the distillation, then replacement of this by mixed injection of steam and hot water. By this means, a constant temperature is maintained, enabling the complete removal of all spirits of turpentine without danger of scorching the rosin.

It can be readily understood that in France, under proper methods of forestry, with conservative tapping of the trees and provision for systematic reforestration, a distillery can look forward to a permanent supply of raw material. Hence there is justification for the more costly plants and more efficient methods of distillation; but in America, where under past methods the industry shifts so rapidly, so great an outlay of capital for this purpose would not be justified. There is no doubt that with an excellent "stiller" very good results can be obtained under the American system, but the personal element of the stiller enters into the question and this could be easily avoided without any great outlay of capital by adopting the French system of mixed injection.

Quite recently M. Castets has erected near Dax, France, a

distillery which combines the features of continuous distillation in a partial vacuum and condensation by pressure of the waste spirits of turpentine vapors from the ordinary condenser in a second condenser attached to the first, thus increasing notably the yield of volatile oil and improving the quality of the rosin.

THE INDUSTRY IN OTHER COUNTRIES.

There is no need of any especial consideration of the Spanish industry, which has developed considerably during the past decade. The operations are essentially the same as the French, and the same species of pine, *Pinus Maritima,* is exploited.

In Austria the industry is more limited and is even more destructive than by the old American system; a "box" being cut in the base of the tree, *Pinus Laricio,* and the trunk of the tree scarified for at least fifty per cent. of its circumference, the oleoresin being directed towards the center of the scarified surface by thin wooden strips inserted in downward cuts in the tree.

In Russia the chief tree exploited is *Pinus Sylvestris.* Climatic conditions do not admit of the usual process of collecting the crude turpentine at regular intervals. Instead, the trees are scarified in the spring over a space about three feet high and almost encircling the tree. During the year a mass of hardened rosin collects on this surface. In the winter it is scraped from the tree and distilled for its volatile oil and resin. This process is repeated for five years. The tree is then felled and the rosinous portion of the tree subjected to destructive distillation. In other districts no effort is made to collect the rosin from the trees annually, but this is allowed to remain until the end of the fifth year of scarification. The tree is then felled and that part containing the rosin distilled first at a low temperature to obtain the volatile oil, then at a more elevated temperature to obtain tar and charcoal by destructive distillation of the wood.

The spirits of turpentine from Germany, Sweden, and Finland, seems to be a product solely of the destructive distillation of resinous wood.

The production of naval stores in India and other tropical countries is at present on too small a commercial scale to call for any detailed discussion here.

WOOD SPIRITS OF TURPENTINE.

Among the various departments of the naval stores industry in America none has had a more varied and interesting career than that of the production of "wood spirits of turpentine" by destructive distillation of resinous wood. Years ago considerable capital was invested in plants for utilizing the by-products formed during the destructive distillation of "fat lightwood." None of the plants were commercially successful and for awhile nothing was heard of the industry. But with the increase in price of spirits of turpentine resulting from the formation of the Turpentine Operators Association in 1902 a fresh impetus was given to the "wood spirits of turpentine" industry. At first somewhat crude methods of destructive distillation were advocated, and as the promoters of this industry appealed largely to local interest in having stumps for distillation removed from fields suitable for cultivation, a double impetus was received. Much enthusiasm was aroused, and a number of plants constructed. But the industry received a serious blow in the refusal of the varnish makers to use the impure "wood spirits of turpentine" manufactured, by the failure to find a market for many of the heavier oils and the coke, and by the destruction by fire of many of the improperly constructed plants.

The price of spirits of turpentine continued to rise and led to the development of the steam extraction process for manufacture of wood spirits of turpentine. After thorough grinding, the wood is treated in iron retorts with steam, and the volatile oil distilled, no effort being made to obtain any other product. By one redistillation of the product a very high grade spirits of turpentine is obtained, equal, if not superior, to that from the living tree. Unfortunately, the yield is not sufficiently large to make the process remunerative.

Quite a different process is employed by those plants which

utilize a bath of molten rosin for removal of the spirits of turpentine from the wood, with subsequent distillation of the volatile oil from this bath. Such plants seem to have met with a fair measure of success.

More recently extraction processes have been developed which employ low boiling petroleum products as the extractive. Such plants recover both the spirits of turpentine and the rosin from the ground wood, and have a great advantage in the present very high value of rosin. These plants are also utilizing the refuse from the straining of rosin at the distilleries in the woods, a product formerly burned on the waste piles, but now bringing nineteen dollars per ton. This method is adding a considerable amount to the annual output of rosin.

The most recent development is a plant for destructive distillation of wood in retorts heated by jackets filled with high boiling petroleum fractions. By this means a fire risk is practically completely eliminated and the results indicate that by means of the complete and ready temperature control of the oil jacket larger yields of better products can be obtained.

ANNUAL PRODUCTION OF NAVAL STORES.

No subject connected with the naval stores industry admits of so little accuracy of statement as does that of statistics on the total annual production. The most careful estimates are at best only approximations. This is unfortunate, for in the past it has frequently led to speculative manipulations of the market and the temporary establishment of values which had no legitimate basis depending on supply and demand.

The following table of annual production is given therefore, as an approximation only, but it is believed to be a reasonably accurate approximation:

	Spirits of Turpentine (barrels 52 gallons)	Rosin (barrels 500 lbs.)
America	600,000	2,100,000
France	100,000	350,000
Spain	25,000	87,500
Austria	3,000	10,500
Other countries	50,000(?)	(?)
Total estimated production . .	778,000	2,548,000

PRODUCTION OF CRUDE TURPENTINE PER TREE.

Here again definite figures are difficult to give, for there is no reliable information concerning the number of trees in operation. Furthermore, there is often very wide variation in the producing power of adjacent trees of the same species, size, and crown. But from the data in the publications of the United States Forest Service, an average American pine, worked under the cup system, will produce, during four years of operation, an annual average of ten pounds of crude turpentine and two and a half pounds of "scrape," the proportionate yield being considerably greater during the first and second than during the third and fourth years of operation.

The average daily flow of crude turpentine during one week from a freshly chipped surface on such pines is shown in the following table, the results having been obtained during the summer of 1901 on trees near Statesboro, Georgia:

	Yield per tree (grams)			Average yield (grams)	Per cent. average yield
Day	1	2	3		
1	113.0	46.5	89.0	82.8	62.9
2	22.5	7.5	16.0	15.3	11.6
3	13.5	6.5	16.0	12.0	9.1
4	9.0	5.0	17.0	7.0	5.3
5 & 6	9.0	5.0	23.0	12.3	9.3
7	1.0	2.0	4.0	2.3	1.8
Total	168.0	72.5	165.0	131.7	100.0

TSCHIRCH'S VIEWS ON RESIN FLOW

As to the seat of resin production and cause of resin flow, most valuable and important views have been advanced by Prof. A. Tschirch in his book "Die Harze und die Harzbehälter," 2nd edition. Tschirch has shown that the seat of resin production is a mucilaginous layer lining the inner walls of the resin ducts. These ducts he divides into two classes: First—primary ducts, whose resin is to be considered a true physiological product. Such ducts occur irregularly and in varying number in any pine. They play only an insignificant role as producers of commerical crude turpentine. Second—secondary resin ducts which form in large numbers in the outer layers of the new wood after a tree is wounded, both above and below the wound. Their oleoresinous exudate is, therefore, a pathological product. It is from such pathological ducts that the great bulk of crude turpentine is obtained.

The application of these views to practical problems in the turpentine forests has already yielded important and fruitful results.

FUTURE OF THE INDUSTRY

During the past few years the statement has frequently been made that from present indications the naval stores industry must cease to exist, at least as a large industry, within the next twenty years. While it is true that there are danger signals which must be heeded, such pessimistic views do not seem to be well grounded.

Certainly in France and consequently in Spain, where the same system is in operation, the industry has been placed upon a self-perpetuating basis.

In America we have been prodigal with our wealth of virgin forest.

But it must be remembered that until the last decade these forests have had a very low commercial valuation. The average price for well timbered lands in our southern states not many years ago was approximately one dollar per acre, land, timber, and all. Indeed, the popular term applied to all holders of

large tracts of such lands was " land poor," as expense of taxation, protection, etc., exceeded any hope of probable profit. This condition was largely due to lack of transportation facilities, insecurity of title, low price of naval stores and lumber, lack of knowledge of the farming value of much of the land on which these forests stood, and the belief that the forests were inexhaustible.

Now conditions have entirely changed. Railroads penetrate every portion of the territory, titles have been cleared, prices of naval stores have brought wealth to the operators, the lumbermen from Michigan, Wisconsin, and other northern states have turned from the rapidly disappearing white pine forests of the north to those of the southern yellow pine; where forests once stood farms have been developed which surpass in fertility any other portion of the southern states, and a clear knowledge has been gained that the forests are by no means inexhaustible. Furthermore, the spirit of conservation of natural resources has made itself felt in this field as well as in those of minerals, water power, etc.

The consequence of these changes has been a very rapid enhancement in the value of such holdings. And with increased valuation comes naturally the desire to protect and use conservatively. Unquestionably, the stand of virgin forest will still further diminish, for the demand for farm lands is active, the call for lumber imperative, and the danger of tropical storms along the Gulf Coast ever present. With such diminution in supply will come still further enhancement in values and still more conservative methods of operation.

So much for the present stand of virgin forest. If the situation were limited to this alone, the outlook might be considered gloomy. But it must be remembered that there are vast tracts of cut-over lands in portions of the southern states whose clay sub-soil lies so deep that the lands are not suited to agriculture. On such lands the longleaf pine, with its long tap root, prospers. Magnificent forests once covered every acre of such lands and fortunately tree planting is not required to reproduce such forests. Nature alone will again cover this territory with a

wealth of forest, provided Nature is given an opportunity; for the most superficial observer who travels through this territory will testify that where conditions have been favorable natural reproduction has brought again splendid, though small, young forests.

Against this willingness of Nature to restore this rich heritage to us, stand three agencies:

First, and of least importance, the consumption by hogs of the delicately flavored and nutritious seed of the longleaf pine. This is a real factor in certain somewhat restricted districts. The constantly spreading sentiment for "stock laws" will check this evil.

Second, and of the very greatest importance, the destructive action of the ground fires, Fig. 7, which annually sweep over the entire turpentine belt. Such fires destroy the myriads of young seedlings which can readily be seen springing up in the wire grass which surrounds them on every side. The seedling devotes the greater part of its early energies to sending down its long tap root through the deep sands rather than to strengthening its stalk above ground; hence, in most cases, it is not able to withstand the constantly recurring ground fires. The doctrinaire may rail against the evils of such firing of the woods, but from one who has lived among the turpentine camps there comes no word of reproach against the turpentine operator who "burns the woods." His all is invested on the outer surface of his trees. A serious outbreak of fire during midseason means financial ruin. The carelessness and sometimes viciousness of laborers is too serious a risk to run with a mass of dead wire grass covering every foot of his territory. Naturally he protects himself by burning this grass when he is prepared for it, after "raking season."

Where then is the hope for reforestration? In the realization of the value of the waste cut-over lands where turpentine operations cannot be carried on for lack of timber. Such lands have now but little value, but the lesson of France shows that even there a reasonable income begins from artificial reproduction within a period of twenty years and then rapidly increases.

With our warm southern climate the prospect for rich returns from such investments should be even greater than in France.

Third, the greed of man. If we are to have a self-perpetuating industry, even stock laws and the reforestration of waste lands will not avail if a practice on the part of turpentine operators during the past two years continues. The abnormally high price of spirits of turpentine two years ago led to a wild scramble for timber for increased operations. At the same time the efficiency of the cup system was just gaining wide recognition. Realizing that a tree too small to have a "box" cut in it could be worked with a cup hung upon it, the operators throughout the whole region proceeded to cup every small tree to which access could be gained. In many cases new farms were opened on old abandoned territory where natural reproduction had furnished thrifty young forests. The result was over-production of crude turpentine. The temporary benefit to the consumers in the drop in values following this over-production was dearly bought, for the price was the destruction of young forests which in time should have produced their full share of the world's need of spirits of turpentine and rosin. Common sense must and will govern in this matter. It is only necessary for the operators to realize that the yield from such saplings does not meet the cost of production, then the practice will cease.

Surely the above considerations justify an optimistic view of the future of the naval stores industry. But experiment, demonstration, statistics, and knowledge of progress made in other lands, must lead the way for the man in the woods.

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THE RESENES OF RESINS AND OLEORESINS*

By Chas. H. Herty and W. S. Dickson

The oleoresinous exudate of pine trees, commonly called "crude turpentine," consists of a mixture of a volatile oil, acids and unsaponifiable matter. On distillation with steam the volatile oil, "spirits of turpentine," passes off; the residual resin, freed from excess of water by heating, solidifies on cooling and constitutes commercial "rosin." The name "resene" has been applied by Tschirch[1] to the non-volatile, unsaponifiable constituent of such resins and oleoresins.

[1] Tschirch, "Die Harze und die Harzbehäeter," Second edition, p. 1079.

Though the composition of crude turpentine varies considerably in different specimens, an average analysis of specimens collected by the usual commercial methods would show approximately:

	Per cent.
Spirits of turpentine	20
Acids	74
Resene	6

Resenes, according to their origin, show varying physical states, some being colorless solids while many are very viscous liquids, extremely sticky and non-crystallizable. They are composed of carbon, hydrogen and oxygen, but the per cent. of oxygen is usually smaller than in the accompanying acids. Toward reagents they are very resistant, especially toward alkalies. Although containing oxygen, they show, according to Tschirch,[2] none of the usual reactions indicating the presence of hydroxyl, carboxyl, aldehyde or ketone oxygen, nor are they ethereal salts or lactones. Tschirch inclines to the view that they belong to the class of exyterpenes or oxypolyterpenes.

While much work has been done upon the volatile oils and the acids of oleoresins, little attention has been paid to the resenes, except ultimate analyses and approximate statements of the proportion present in isolated specimens studied. In connection

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[2] *Loc. cit.*

with an investigation carried out in this laboratory in collaboration with the United States Forest Service, there remained a large number of specimens of resin from well identified individual trees growing in Florida. It seemed desirable, therefore, to study more closely the question of the proportions of resene in these specimens. The investigation was extended to the resins of conifers growing near this laboratory, and to specimens collected in other countries. Finally the amount of resene was determined in several oleoresins obtained in perfectly fresh condition from individual trees in Florida. These specimens were collected from the two species of pines from which crude turpentine is commercially obtained in this country, *Pinus Palustris* (Longleaf Pine), and *Pinus Hetrophylla* (Cuban or Slash Pine).

The resins were obtained by distilling the oleoresins in a current of steam slightly superheated, the temperature being raised to 140° C. toward the end of the distillation. After complete removal of the volatile oil, the residue was kept at 140° C. in the oil bath surrounding the distillation flask until all water was driven off. The molten resin was then filtered through absorbent cotton and cooled to solidification in glass or iron molds.

The determination of resene in the resins was carried out in the usual manner. The weighed specimen, about two grams, was dissolved in a considerable excess of $N/2$ alcoholic potassium hydroxide, allowed to stand at room temperature eighteen hours, diluted with water until separation of the resene began and the solution cleared by the addition of a small quantity of ninety-five per cent. alcohol. This solution was then extracted three times with petroleum ether, boiling below 40°c. The combined extracts were shaken out with fifty per cent. alcohol to remove slight amounts of dissolved potassium salts of resin acids. After drawing off the petroleum ether extract into a weighed glass evaporating dish, it was allowed to evaporate spontaneously to constant weight.

In the case of the oleoresins, after spontaneous evaporation of most of the petroleum ether, the residue was heated for five hours on a steam bath in order to remove completely the petro-

leum ether and the volatile oil. Considerable difficulty was experienced at the outset in these evaporations due to the tendency of the material to "crawl" over the rim of the vessel. This was entirely overcome by using a thin coating of vaseline on the rim of the vessel.

The following results were obtained:

TABLE I.—PER CENT. OF RESENE IN RESINS FROM DIFFERENT SPECIES

Species.	Local name.	Origin.	Per cent. resene.
Pinus Taeda	Loblolly Pine	North Carolina	4.10
" Palustris	Longleaf Pine	Florida	5.67
" Maritima	Maritime Pine	France	7.37
" Heterophylla	Cuban or Slash Pine	Florida	7.38
" Serotina	Pond Pine	Florida	7.65
" Echinata	Old Field Pine	North Carolina	8.71
" Species unknown		Central America	8.94
" Sabiniana	Digger Pine	California	9.66
" Laricio	Schwarzkiefer	Austria	14.05

In order to test the variation of the amount of resene in trees of the same species two sets of determinations were carried out on trees of different diameters. The results follow:

TABLE II.—PINUS PALUSTRIS (LONGLEAF PINE).

Tree No.	Diameter (inches).	Per cent. resene in resin.
1	7.3	5.26
2	15.0	5.95
3	21.0	9.68
4	13.0	7.45
5	8.7	5.67
6	9.0	5.45
7	13.5	6.22

TABLE III.—PINUS HETEROPHYLLA (CUBAN OR SLASH PINE).

Tree No.	Diameter (inches).	Per cent. resene in resin.
1	7.0	7.87
2	14.5	7.36
3	24.5	7.20
4	12.3	7.25
5	8.2	6.58
6	13.0	7.84
7	9.0	7.00

To determine possible variations in the per cent. of the resene in different seasons of the same year two trees were selected, one each, *Pinus Palustris,* tree No. 2, Table II, and *Pinus Heterophylla,* tree No. 2, Table III. Beginning in the early spring

the oleoresins were collected from these at regular periods of four weeks until the close of the season in the fall. From the resins prepared from these specimens the following results were obtained:

TABLE IV.

Collection No.	Per cent. resene in resin from Pinus Palustris.	Pinus Heterophylla.
1	5.31	7.36
2	5.44	7.67
3	5.95	7.23
4	6.02	8.17
5	6.09	7.38
6	6.53	7.43
7	5.24	7.77

It is scarcely probable that in the case of *Pinus Palustris* any significance is to be attached to the gradual increase in the per cent. of resene as the season advanced until the last collection.

Further determinations were made of the per cent. of resene in specimens of oleoresin collected with great care in Florida and promptly analyzed. The following results were obtained:

TABLE V.

Tree No.	Per cent resene in oleoresin of Pinus Palustris	Pinus Heterophylla
1	7.10	6.83
2	3.84	6.76
3	7.33	6.96

Finally, a specimen of "scrape" (Gum Thus) was obtained from a Longleaf pine (*Pinus Palustris*). This scrape is the hardened mass which gradually collects on the scarified surface of the tree as a result of the crystallization of the resin acids of the oleoresin. It receives its name from the fact that at the end of the season it is scraped from the surface of the trees by means of a sharp tool. It contains approximately one-half as much spirits of turpentine as the ordinary oleoresin collected from the receptacles. The resin was prepared from this scrape by distillation with steam as above. On analysis it showed 3.14 per cent. of resene.

In continuation of this work, there is now being carried out in this laboratory an investigation of the composition of the resene of *Pinus Heterophylla*.

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THE VALUE OF COMMERCIAL STARCHES FOR COTTON MILL PURPOSES.

By G. M. MacNider.

Large quantities of starch are used annually by the cotton mills in the processes of sizing and finishing. The yarn is prepared for weaving by a process known as sizing, in which it is treated with a solution of starch to give it certain properties essential to good weaving. When the cloth comes from the loom it is put through a process known as finishing to produce a certain "finish" before it is ready for the market. It is essential to good weaving that the yarn be properly sized before going to the loom and with many grades of cloth the finish produced by the starch largely determines the market price of the goods. It is therefore seen that starch plays a very important part in the manufacture of cotton goods, and hence the purchase of the kind of starch best adapted to the purpose in hand is a very important matter.

The object of sizing is to make the yarn stiffer, increase the strength and put it into proper condition for weaving. To accomplish this the size must penetrate the yarn to some extent and also form a coating on the surface of the thread, which prevents wear of the thread in the loom. The size is prepared by boiling the starch (and other ingredients) with water in an iron kettle known as the size-kettle. When the mixture has been boiled for a sufficient length of time it is run out into the size-box of the sizing machine and kept hot while the yarn is passed through it. Two systems of sizing are in use: the short chain system, or old system, in which the yarn is sized in hanks, and the long chain or slasher system in which the yarn is sized from the beam. The same results are obtained by both systems, the slasher system being faster than the short chain system. In both systems the yarn is dried as soon as it comes from the starch solution.

The object of finishing is to increase the stiffness of the cloth and produce a finish and feel on the cloth which are very import-

ant factors in marketing cotton goods. The finish mixture is prepared in a manner similar to the size mixture and is applied to the cloth while hot. When the cloth is dry it is calendered to bring out the finish. The use of a starch solution alone in these operations would make the goods too stiff and produce a harshness which is not desirable. To modify this effect many softening agents are used, such as tallow, oils, soaps, glycerine, etc. As finishing is the final operation it is very important that it should be properly carried out and the best effect obtained from the starch. If it is desired to increase the weight of the goods this can best be done in the finishing process. For this purpose the finishing mixture is made very thick, or where this would produce too much stiffness in the cloth thin boiling starches may be used to give the weight without undue stiffness.

The principal starches used in the textile industry are corn, potato, cassava, sago, and to a small extent wheat and rice. Wheat and rice starches are, however, more largely used as laundry starches.

The value of starch for cotton mill purposes depends on its property of swelling and forming a viscous solution when treated with hot water. It is well known in practice that the different starches produce different effects in sizing and finishing. One kind of starch will penetrate the goods better than another. This variation is due to a difference in the thickness of the solutions formed by the different starches when boiled with water, that is, one starch forms a more viscous solution than another. The thickness or viscosity of the solution formed by starch is the most important point to be known in determining the value of a starch for textile purposes, for on this depends the penetration of the starch solution into the yarn or cloth, and hence the stiffness which will be given to the goods when sized or finished. As the viscosity of the starch solution is such a valuable indication of the value of the starch it is very important to have a method for determining the viscosity which will give results comparable to actual practice. The following method has been devised for this purpose:

Twelve grams of the starch are weighed into a 600 cc. beaker,

300 cc. distilled water added (thus making a 4 per cent. solution) and heated with constant stirring to the boiling point and boiled for ten minutes; 200 cc. of this solution are then poured into the cup of a Scott viscosimeter, the temperature allowed to become constant, usually 94° C., and 50 cc. run out into a graduate, the time being accurately measured with a stop watch. The number of seconds required to deliver 50 cc. of the solution divided by the number of seconds required to deliver 50 cc. of boiling water gives the viscosity.[1]

It will be noticed from this that the starch solution is prepared by boiling with water as is done in sizing and finishing and the viscosity is measured at very near the boiling point of the solution, so that the figures obtained show the effect of boiling on the different starches.

The viscosities of the principal commercial starches are shown in the following table.

TABLE I.—VISCOSITIES OF COMMERCIAL STARCHES.
(12 grams starch in 300 cc. water, boiled ten minutes.)

Starch	Viscosity
Corn	3.05
Potato	14.31
Cassava	3.92
Sago	1.57
Wheat	1.25
Rice	1.00

From the above table it is seen that there is a wide variation in the viscosities of the different starches and hence a wide variation in their value for mill purposes. The viscosity of potato starch is much higher than that of any other starch, but there is also a considerable variation between the viscosities of the other starches. The importance of the viscosity will be seen more fully in the next section in showing the effect of boiling on the viscosity of starch solutions. It has been found that there is frequently considerable variation in the viscosities of different lots of the same kind of starch. It would be very advantageous to the mills for each lot of the same kind of starch to have a uniform viscosity. This would make it possible to

[1] A detail description of this method was published in the *Journal of Industrial and Engineering Chemistry*, Vol. IV, No. 6, 1912.

obtain the same results in sizing and finishing without changing the formula for each lot of starch.

In practice the starch solution is boiled from thirty minutes to one hour before being used. It is therefore very important to know the effect produced by boiling on the viscosity of the starch solution. This is shown in the following table.

TABLE II.—SHOWING THE EFFECT OF BOILING ON THE VISCOSITIES OF COMMERCIAL STARCHES.

(12 grams starch in 300 cc. water.)

Starch	Minutes Boiled	Viscosity
Corn	at boil	2.15
"	10	2.73
"	20	4.26
"	30	7.00
Potato	at boil	16.37
"	5	19.51
"	10	14.31
"	30	6.33
Cassava	at boil	9.93
"	5	4.53
"	10	3.88
"	20	3.91
"	30	4.17
Sago	at boil	1.88
"	5	1.62
"	10	1.57
"	30	1.66
Wheat	at boil	1.20
"	5	1.22
"	10	1.26
"	20	1.24
"	30	1.33
Rice	at boil	1.00
"	10	1.00
"	30	1.08

From the above table it will be seen that the viscosity of corn starch increases uniformly with the length of time of boiling. This increase is about what would be expected with the concentration of the solution when there is no change in the starch. This is a very valuable property of corn starch as compared with other starches and gives corn starch a much wider application in the textile industry than any other starch. The value of this property will be seen more clearly by comparison with potato starch.

Potato starch reaches its maximum viscosity after being boiled five minutes. From this point the viscosity decreases

rapidly with the increase in time of boiling, the concentration of the solution apparently having no effect on the viscosity. After boiling ten minutes potato starch has a viscosity slightly more than five times as great as corn starch, while after boiling thirty minutes the viscosity of potato starch is less than that of corn starch which has been boiled the same length of time. This property of potato starch of liquefying on boiling is a very important point to be considered in using this starch. In sizing the starch is boiled from thirty minutes to one hour before being used, hence, as will be seen from the table, a size mixture made of potato starch will have a viscosity less than that of a similar size made of corn starch at the time it is ready to be applied to the yarn. In other words, the potato starch size will not be as valuable for sizing as the corn starch size, but it will cost approximately twice as much as the size made from corn starch.

Cassava starch attains its maximum viscosity at the boiling point. The solution apparently has a higher viscosity shortly after complete gelatinization takes place, but no measurements were made of this as the starch is not used until it has been boiled. After reaching the boiling point the viscosity decreases uniformly with the length of time of boiling. After boiling thirty minutes there is an increase in the viscosity over that of the solution boiled twenty minutes. This increase is probably due to increase in concentration. As will be seen from the table, cassava starch behaves in a manner very similar to potato starch as regards liquefaction of the solution, but not to the same extent. Cassava starch therefore has a much broader application in sizing and finishing than potato starch.

Sago starch has a much lower viscosity than any of the starches so far considered. Like cassava starch it apparently has a higher viscosity at the time of complete gelatinization, but no measurements were made of this. The viscosity is highest at the boiling point and decreases uniformly on boiling, though not to the same extent as the other starches. After boiling thirty minutes there is a slight increase in viscosity due to the concentration of the solution. While having a consider-

able lower viscosity sago starch is quite similar to cassava starch as regards the effect of boiling on the solution.

Wheat starch shows a gradual increase in viscosity with the time of boiling, similar to corn starch, though the total increase is small, the viscosity of the thirty minute determination being only slightly higher than the determination made at the boiling point.

Rice starch has the same viscosity as water when measured under these conditions. At the end of thirty minutes boiling it shows only a very slight increase in viscosity.

The marked differences in the effect of boiling on the viscosities of the different starches is due to the fact that some starches form soluble starch products more readily than others. The data given in the preceding table shows very plainly the importance of the viscosity in determining the value of a starch for mill purposes.

SPECIAL OR TREATED STARCHES.

A number of special starches are now used which have been treated so as to make them "thin boiling starches," that is, when boiled the solution has a lower viscosity than the natural starches. These usually consist of corn starch which has been treated in some way to reduce the viscosity. The viscosities of several such starches are shown in the following table:

TABLE III.—VISCOSITIES OF SPECIAL OR TREATED STARCHES.[2]
(12 grams starch in 300 cc. water, boiled ten minutes.)

Starch	Viscosity
Eagle Finishing	1.15
N Starch alkaline	2.13
Famous N	1.17
Erkenbrecher's Modified	1.13
T. B. Crystal No. 75	1.11
T. B. Crystal No. 90	1.04
Special Warp Sizing	3.48

There are quite a number of processes for treating starches to reduce the viscosity or make them thin boiling starches. In the table above the Eagle Finishing Starch is a treated starch

[2] The samples of treated starches were very kindly furnished the author by the Corn Products Refining Co., of New York.

containing a small amount of borax and is slightly alkaline. The viscosity of the alkaline N starch has been reduced by the addition of a small amount of alkali. The other starches given in the table have been treated to reduce the viscosity and are neutral in reaction. The effect of several reagents on the viscosity of starches has been shown in a previous paper.[3]

It will be seen from this table that the viscosities of the treated starches cover quite a wide range, from a viscosity slightly less than that of corn starch to a viscosity only slightly higher than water. The Special Warp Sizing Starch is a pulverized corn starch. It is frequently claimed that pulverized starch makes a smoother size mixture than the ordinary granular starch. These treated starches, on account of having lower viscosities than untreated starches, are of value in sizing and finishing to obtain more penetration of the starch into the yarn or cloth and to increase the amount of starch which is put into the goods. This may be accomplished by using the treated starch in place of the untreated and increasing the amount used or by mixing the treated starch with the untreated starch in such proportion as to secure the desired results. For instance, in sizing or finishing if the mixture contains 50 lbs. of corn starch to 100 gallons of water and it is desired to increase the amount of starch put into the goods nearly double this amount of a thin boiling starch could be used which has a viscosity of half of that of corn starch and still obtain a size mixture with the same thickness or viscosity as with the 50 lbs. of corn starch. In other words nearly twice as much starch would be put into the yarn, thereby increasing the weight of the yarn, by using the thin boiling starch than by using the untreated corn starch. This is shown in the following formulae for sizing No. 26 yarns which are taken from actual practice:

100 gallons water
50 lbs. corn starch.

100 gallons water
95 lbs. Eagle Finishing Starch.

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[3] *Journal of Industrial and Engineering Chemistry*, Vol. IV, No. 6, 1912.

It will be noted from the table of viscosities that Eagle Finishing Starch has a viscosity slightly less than half of that of untreated corn starch and hence when this starch is used the amount can be nearly doubled without effecting the penetration.

By comparing the following formula for sizing No. 26 yarns with the first formula given it will be seen how the amount of starch may be increased and at the same time obtain greater penetration and more weight than with untreated corn starch.

100 gallons water
80 lbs. Eagle Finishing Starch.

The following formula for sizing No. 26 yarns shows the use of another treated starch:

100 gallons water
65 lbs. Alkaline N Starch.

It will be noted from the table of viscosities that this starch has a viscosity of 2.13 or slightly lower than corn starch and hence a larger amount of it can be used.

In making investigations on the value of the different commercial starches for cotton mill purposes the author has received very valuable assistance from many of the cotton mills in the State. A large number of mills have very kindly sent in reports showing the kind of starch which they use and the method of preparing the starch for sizing and finishing. Below are given a number of typical formulæ for sizing by the long chain or slasher system which are in actual use by the mills. For convenience of comparison the formulæ have been calculated to a basis of 100 gallons of water. As there is such a great variety of softening agents in general use by the mills the amount of softener has not been included in the formulæ. The average amount of softener used in sizing is approximately 15 lbs. of tallow, or its equivalent, to 100 lbs. of starch or 1.5 lbs. to each 10 lbs. of starch. The amount used varies, of course, with the yarn numbers and the method of sizing.

For yarn Nos. 14 s and 20 s.

100 gallons water
66 lbs. Eagle Finishing Starch.

For yarn Nos. 14 s and 22 s.

100 gallons water
71 lbs. Eagle Finishing Starch.

These formulæ are used on practically the same yarn numbers. The first one, using 66 lbs. of starch will give greater penetration than the second, but the second formula will give more weight to the yarn.

For yarn No. 16.

100 gallons of water
63 lbs. corn starch.

In this formula, using an untreated starch, a smaller quantity of starch is used than in the other formulæ where treated starch is used.

For yarn No. 21.

100 gallons of water
62 lbs. corn starch.

For yarn No. 23.

100 gallons of water
60 lbs. corn starch.

For yarn No. 26.

100 gallons of water
50 lbs. corn starch.

100 gallons of water
95 lbs. Eagle Finishing Starch.

100 gallons of water
80 lbs. Eagle Finishing Starch.

100 gallons of water
65 lbs. Alkaline N Starch.

These formulæ for 26 s show how different starches may be used to increase the penetration and vary the amount of starch put into the yarn, thereby increasing the weight of the yarn.

For yarn Nos. 28 s and 36 s.

100 gallons water
65 lbs. Potato starch.

For yarn No. 28½.

100 gallons water
80 lbs. Famous N Starch.

For yarn No. 30.

100 gallons water
65 lbs. Famous N Starch.

100 gallons water
65 lbs. corn starch.

These formulae for 30 s show how more penetration and hence more weight may be obtained by using a thin boiling starch in place of an untreated starch.

For yarn No. 36.

100 gallons water
48 lbs. potato starch.

For yarn No. 40.

100 gallons water
65 lbs. Eagle Finishing Starch.

100 gallons water
70 lbs. potato starch.

In comparing the amounts of starch used in the different formulæ the viscosity of the different starches should be kept in mind as it will be noted that when large amounts of starch are used the treated or thin boiling starches are used in place of the untreated starch which has a higher viscosity.

In sizing by the short chain system more starch is required and a thicker solution is used than in sizing by the long chain or slasher system. This is due to the fact that the yarn is not stretched as much in short chain sizing as it is on the slashing machine and hence the starch solution penetrates the yarn more readily. For example, a size mixture composed of 120 gallons

of water, 65 lbs. starch and 8 lbs. of tallow will size about 720 lbs. of No. 14½ yarn by the short chain system, while by the slasher system the same amount of size will be sufficient for about 950 lbs. of the same yarn.

In preparing the starch for use it is very important that the size be thoroughly boiled before being used. In the reports which the author has received from the cotton mills it is always recommended to boil the size mixture from thirty minutes to one hour before using. From this it is safe to say that the size mixture should be boiled for not less than forty-five minutes before being used.

From the data which has been presented in this article it is seen that the viscosity of the starch solution is the important point to be considered in determining the value of a starch for textile purposes. There is another property of starch which is of value in the textile industry which is not shown by the viscosity, that is the finish which is imparted to the goods by the starch. Potato and cassava starch are said to produce a smooth finish, while corn and rice starch are said to produce a harsh finish. While this property may be of value in sizing and finishing some grades of goods, still no matter which one of the starches is used some softening agent must be used with it to modify the effect of the starch and it is therefore best in the majority of cases to use a cheap starch and control the finish by the use of softeners than to control the finish by varying the kind of starch used.

Sufficient data has been given to show the value of the different starches for textile purposes. There is a wide variation in the viscosity of the different starches and in the effect of boiling on the viscosities and as this is such an important factor in sizing and finishing it must be taken into consideration in selecting the starch to be used in cotton mills. As starch plays such an important part in the manufacture of cotton goods it is very important for the manufacturer to use the kind of starch which will produce the desired results most economically.

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NOTE ON THE TRANSFORMATION OF AMMONIUM CYANATE INTO UREA.*

Chattaway[1] says, "The course of the reaction which takes place when ammonium cyanate is transformed into carbamide has never been satisfactorily explained. Up to a few years ago it was universally regarded as a peculiar case of isomeric change and no consideration was given to the process by which the conversion was effected." He then states that various specified reactions of carbamide, cyanic acid, isocyanic acid and their esters may be simply explained "by regarding them as instances of the well known tendency of the carbonyl group to add groups such as R_2NH and ROH, followed by a subsequent atomic rearrangement involving only the transference of a hydrogen atom from an oxygen atom to a nitrogen atom connected with it through the doubly linked carbon atom, thus:

$$N{:}C{:}O \quad \rightarrow \quad \cdot N{:}C{<}{\begin{matrix} OH \\ N: \end{matrix}} \quad \rightarrow \quad \cdot NH \cdot CO \cdot N:$$

The conversion of ammonium cyanate into carbamide should therefore be formulated as follows:"

$$NH_4 \cdot N{:}CO \rightleftarrows H \cdot N{:}C{:}O + NH_3 \rightleftarrows H \cdot N{:}C{<}{\begin{matrix} OH \\ NH_2 \end{matrix}} \rightleftarrows H_2N \cdot CO \cdot NH_2$$

The three stages, then, in the transformation are (1) the breaking up of ammonium cyanate into cyanic acid and ammonia, (2) the formation of an addition compound, and (3) a rearrangement of this compound.

A simpler explanation eliminates this addition compound and its rearrangement. I find in my note book on the lectures in Organic Chemistry by Professor H. B. Hill at Harvard University in 1896, this statement: Ammonium cyanate breaks up with heat into HNCO and NH_3 and then the NH_3 adds itself as follows:

$$\begin{matrix} H.N{:}C{:}O \\ \uparrow \;\; \uparrow \\ H \;\; NH_2 \end{matrix} = H_2N \cdot CO \cdot NH_2$$

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* Reprinted from *The Journal of the American Chemical Society,* Vol. XXXIV, No. 9, September, 1912.

I have used this explanation in my own lectures since that time. Essentially the same explanation is given by Willstätter in his lectures in Zürich. By introducing the idea of partial valence the mechanism is more readily conceived. The reaction is formulated thus:

The partial valences of the nitrogen and carbon atoms are represented by a number of very short lines, not dots, which should be reserved for ordinary valences. (The practise of writers in this matter is not uniform, but uniformity would be very desirable.) When the partial valences come into play in the presence of $H.NH_2$, one of the double bonds between nitrogen and carbon is broken, as represented in lecture practise by a double stroke across the bond and the partial valences resolve themselves into ordinary valences.

ALVIN S. WHEELER.

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NEW THERMOMETERS FOR MELTING POINT DETERMINATION.*

Uniformity in practise in making melting point determinations would be very desirable, for even to-day there are too many cases where different observers disagree. The failure to agree is not always due to the quality of the material if we may have confidence in the analytical data given. Many forms of apparatus are in use as well as various kinds of thermometers. Other factors also enter in. The practise of reporting the corrected reading is a step in the right direction and its extension should be constantly urged.

In order to avoid the necessity of making corrections for the exposure of the mercury column I have devised a thermometer with a short scale, so that it may be completely immersed in the bath. The method of construction may be readily seen from the accompanying sketch. Owing to the compact form of the scale it was necessary to construct a set of seven thermometers, each with a milk glass scale of 50^0 with divisions in degrees. The length of the scale is 35 mm. The thermometer jacket is lengthened so that the total length is 20 cm. This permits of its suspension by means of a cork as in the Thiele apparatus which is a particularly good form to be used with this thermometer. The mercury bulb is small and compact and above it is a constriction to enable one to attach the capillary tube if that is desired. For the protection of the manufacture of the thermometers patent No. 507,320 has been entered in the German Patent Office. The thermometers may be obtained from C. Richter, 30 Lehrterstrasse, Berlin, N. W. 5.

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Recording Secretary.

NEW OCCURRENCES OF MONAZITE IN NORTH CAROLINA

By Joseph Hyde Pratt

In 1897 there was forwarded to the office of the North Carolina Geological Survey a package containing a sample of mineral for identification. No letter accompanied this package and the only clue to the locality from which the mineral came was the postmark, which was Mars Hill. The mineral was turned over to the writer for examination and was found to be monazite. There were a number of fairly well developed crystals of unusual size; but the majority of the pieces of monazite did not show any crystal facies but were pseudo-crystalline, due to parting parallel to *c* and *m*. An attempt was made to locate the sender of the specimens without success and although many inquiries were made in and around Mars Hill, and the vicinity had been visited a number of times, no clue to the occurrence of this monazite was obtained until in the fall of 1908 when another specimen of monazite was seen by the writer while travelling in Madison County. A systematic search was then begun for the mineral with the result that the occurrence was definitely located.

References have been made to the occurrence of monazite at Mars Hill, Madison County, by F. A. Genth,* who states that monazite occurs in "large cleavable masses sometimes from 3 to 4 inches across and of a yellowish brown color from Mars Hill, Madison County." He does not, however, give any further statement regarding locality. In Dana's Mineralogy† it is stated that monazite occurs "in considerable quantities in Madison County, North Carolina, yielding angular fragments due to parting." Judging from these brief notices of monazite in Madison County, it is very probable that the specimens of monazite found at that time were picked up on top of the ground by some of the farmers in the vicinity of Mars Hill and no record was kept as to where they were actually obtained.

* Bull. 74 U. S. Geological Survey, 1891, p. 77.
† 6th ed., 1892, p. 752.

Judging from the occurrence of monazite in the South Mountain region of North Carolina where it was known to occur in the gneissic rocks and especially in those portions that have been pegmatized, instructions were given to the men assisting in locating the monazite of Madison County to look for it in the gneissic or granitic rocks that were more or less pegmatized. The occurrence of this monazite was finally located on a hill to the west of Whiteoak Creek, a branch of Ivy River approximately 3 miles southwest of Mars Hill and 6 miles nearly due east of Marshall, on a tract of land owned by Mr. N. P. M. Corn.

The country rocks of this section are Carolina gneiss and Cranberry granite named and described by Mr. Arthur Keith.* The Carolina gneiss is of Archean age and consists chiefly of mica gneiss and mica schist but includes other gneisses, granites and diorites with small lenses of marble. The origin of this Carolina gneiss is uncertain, but it is possible that most of the mass was once a granite and that it has been metamorphosed into its present condition. In this particular vicinity this Carolina gneiss occurs as outliers from the main formation and is not inter-banded with the Cranberry granite. Immediately to the east there is a large mass of Roan gneiss and this is also observed further to the west. The Cranberry granite as it occurs in this vicinity is also in the form of outliers or apophyses from the main mass lying to the north and west. As described by Mr. Keith, this granite is an igneous rock composed of quartz and orthoclase and plagioclase feldspar with biotite, muscovite and, in places, hornblende as additional minerals. There are a number of accessory minerals as magnetite, ilmenite, garnet and epidote. This granite occasionally contains pegmatite areas and, on the Whiteoak Creek, a great deal of the gneiss and granite was pegmatized.

There are no extensive areas of rocks outcropping on this hillside. Occasionally small boulders of the partially decomposed granite were observed containing more or less epidote and ilmenite forming a sort of a ledge running around the hill about a third of the way to the top. About 100 feet up the hillside a

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* U. S. Geological Survey, Asheville Folio, No. 116, 1904, pp. 2 and 3.

shaft has been sunk to a depth of 45 feet. The rocks were decomposed throughout this distance so that no blasting whatever was necessary. On account of the excessive decomposition of the rocks, it was difficult to determine what the rocks at this particular point were. They had the appearance, however, of being decomposed Cranberry granite. The section exposed by the shaft showed the rocks to be more or less pegmatized and to carry monazite the whole depth of the shaft. The monazite seemed to occur in the pegmatized band of the rock, which, in the shaft as exposed, had a width of 2½ to 4 feet.

The monazite, which is of a clove brown color, was found in fragments of rough crystals varying from pieces the size of a pea up to a large rough crystal that weighed almost exactly 60 pounds. No attempt was made at this time to determine the percentage of monazite that the rock would carry. One or two pans full of the monazite-bearing portion of the rock were taken out, which gave nearly a pound of monazite.

As stated above, the monazite is in the form of irregular fragments, rouch crystals and cleavable masses. One of the best crystals observed was a part of a mass that weighed 6½ pounds, which was made up of crystals in parallel position with some of the facies very perfectly developed. Another crystal, which was well terminated, weighed 12 ounces. It was 2¾ inches long in the direction of the *b* axis; 1½ inches in the direction of the *a* axis and 2¼ inches long in the direction of the *c* axis. The prismatic facies of the *a* pinacoid were well developed as was also the unit pyramid *w*. The lower end of the crystal showed no terminations. The facies observed on these crystals were identified by means of the contact goniometer and were as follows: *a* (100); *m* (011); *w* (101) *v* ($\bar{1}$11).

The basal plane *c* was not observed on any of the crystals but was observed as one of the parting or cleavage planes. Parting planes were also very prominently developed parallel to *m*.

The masses of the monazite were very pure and one analysis to determine the percentage of monazite in the masses shows it to contain 99.5 per cent. monazite. No chemical analyses have been made of the mineral beyond the determination of thoria.

This determination, which was made in the laboratory of the Welsbach Light Company, showed this monazite to contain 5.06 per cent. thoria, which is equal to the percentage of thoria in the best commercial monazite found in the South Mountain region.

The size of the crystals of monazite found in this deposit, which are perhaps the largest on record, make this discovery a most interesting one.

CHAPEL HILL, N. C.

NATURAL HISTORY NOTES ON SOME BEAUFORT, N. C., FISHES, 1910-11.

No. III. Fishes New or Little Known on the Coast of North Carolina. Collected by Mr. Russell J. Coles*

By E. W. Gudger

The ichthyological events of the years 1910 and 1911 in the Beaufort region were the expeditions of Mr. Russell J. Coles, of Danville, Va., to Cape Lookout. As previously stated (Gudger, 1912) Mr. Coles has been fishing in the waters of Beaufort and surrounding parts for many years. In July, 1909, seeking especially for rare forms, he fished extensively and effectively at the Cape, so effectively (he added *Narcine brasiliensis* to our fauna) that he came back in 1910 as volunteer collector of fishes for the American Museum of Natural History. With a larger force of men and a fuller equipment of boats, nets, and other apparatus, he was extraordinarily successful, taking during the season (1910) a total of 77 species, of which 5 were new and a larger number but sparingly recorded in the literature as found on our coast. In 1911, Mr. Coles sought not to take a large number of species, but rather to collect new forms or those but little known to the coast of North Carolina. As to the former, he was successful in adding 8 new species, of the latter fishes he took quite a number. In all his additions to our fauna number no fewer than 14.

A brief statement of the data collected by Mr. Coles will now be given. It is in part taken from his paper published by the American Museum (1910), but mainly it was communicated by him to the writer personally. Some of these data have already been given in the preceding papers of this series (Gudger, 1912, 1912a), in connection with the writer's own observations. The fishes named, which were taken in 1910, were presented to the American Museum of Natural History, while

* Parts I and II of this series, bearing sub-titles "Elasmobranchii—with Special Reference to Utero-gestation" and "Teleostomi" respectively, have been published in the Proceedings of the Biological Society of Washington, Vol. 25, 1912. See under *literature cited* at the end of this article.

the collection of 1911 was divided between that institution and the United States National Museum. The identifications are by Messrs. John T. Nichols and Barton A. Bean, curators of fishes in these two great museums.

SPECIES NEW TO NORTH CAROLINA.

Carcharhinus acronotus (Poey).

Sharp-backed Shark.

About the middle of July, 1911, Coles took in the bight of Cape Lookout a small greenish shark about 3 feet long. The identification of this fish being in doubt, it was referred to that veteran student of the Elasmobranchs. Dr. Samuel Garman, who pronounced it to be *Carcharhinus acronotus,* heretofore only described from Havana by Poey. Not only is it new to North Carolina waters but so far as the writer knows to the coast of the United States.

Carcharhinus limbatus (Müller and Henle).

Caconetta.

In July, 1910, Coles collected at the Cape a shark which was afterwards identified as *Carcharhinus limbatus.* This is the first reported capture of this fish in our waters and, so far as the writer knows, the second for the Atlantic coast—according to Jordan and Evermann (1896) a single specimen having been taken at Woods Hole in the early '80s.

Whether the unknown shark referred to on page 141 of the first paper of this series (Gudger 1912) is identical with either of the above fishes cannot of course be said. If it should be, then the writer by a faulty diagnosis lost the opportunity to add it to the list of North Carolina fishes. But, as stated previously, sharks are so variable that the classification was not pushed farther and the fish was thrown aside as a variation.

Narcine brasiliensis (Olfers).

Numb-fish.

During his trip to Cape Lookout, in 1909, Mr. Coles, added to our fish fauna by collecting and bringing to the laboratory of the United States Bureau of Fisheries (sub-

sequent to the writer's departure therefrom) two fine specimens of *Narcine brasiliensis,* variety *corallina,* a fish hitherto unknown in our waters. Director H. D. Aller has already called attention to this interesting find (1910), but it seems not out of place here to make mention of this fact and to note certain details of the structure of this fish.

When examined by the present writer, these specimens had been in formalin in a copper tank for 11 months, but were in perfect condition save that they had been dyed a beautiful green by the copper salts. The male was 11 inches long over all, 5½ inches to the end of the ventrals, and the greatest width of the disk was 6⅛ inches. The claspers were short, barely projecting beyond the ventrals, but the grooves for the transmission of the milt were quite plain. The female was 13½ inches long, half of that distance being the length of the tail clear of the ventrals. The greatest width was 7⅜ inches, and the widths (inside measurements) between spiracles and eyes were 15-16 of an inch and 1 7-16 inches respectively. In both, the tails were fringed with side fins, like the bilge keels of a vessel, from the middle of the anterior dorsal to well beyond the base of the caudal. The spiracles were placed immediately behind the eyes. The jaws were set on a short peduncle in the mouth and were surrounded by a fossa. This indicates that they are probably protrusible. Through the kindness of Director Aller, both specimens were examined for reproductive organs. Unfortunately, however, these were either immature or so out of season that nothing could be made out. However, the fish is known to be viviparous. Concerning this attention is called to Bean and Weed's interesting paper (1911).

In July, 1910, Coles (1910) captured in the same locality and preserved for the American Museum of Natural History 11 specimens of these interesting animals, while at least a dozen more were taken by the fishermen. These were all caught within one week, and after that time none could be found. Coles reports that they bury themselves up to the eyes in sand, and that he saw barefoot fishermen knocked down by stepping on them while wading about in the shallow water.

In 1911, Coles took only 5 of these interesting rays. One he gave to the writer, three were presented to the U. S. National Museum, and one sent to the Museum d'Histoire Naturelle at Paris. These rays were caught on precisely the same days as those in 1909 and 1910, viz., from June 29 to July 4, after which none were taken in any of these three years either by Mr. Coles or by the fishermen.

The specimen presented to the writer was 7½ inches wide, 7 inches long, 9½ to end of ventrals, and 13¾ over all. The width between its eyes was 1½ inches and the width of its mouth ⅞ inch. The electric organs were each 3⅞ inches long by 2⅛ wide. The reproductive organs were immature or at any rate non-functional. The stomach and intestine were filled with common red annelid worms. The other structures were as in those previously described.

This is the first time that this interesting fish has been taken in the waters of North Carolina. Jordan and Evermann (1896) say of it (vol. I, p. 78): "West Indies and Brazil, occasionally northward to Key West and Pensacola."

Urolophus jamaicensis (Cuvier).

In addition to *Narcine brasiliensis,* Coles has added two other new rays to our North Carolina fauna. The first of these is *Urolophus jamaicensis,* a West Indian form of which Jordan and Evermann (1896) say . . . "once (perhaps erroneously) recorded from New Jersey." Coles' specimen, measuring about 3½ inches across the disk, was taken at Cape Lookout the last week in June, 1911. It was presented to the American Museum of Natural History.

Dasyatis hastata (De Kay).

Sting Ray.

The other new ray referred to is *Dasyatis hastata,* a female specimen of which weighing 64 pounds Coles took at the Cape in July, 1910. While being killed, she gave birth to five young about 6 inches wide and 15 long (including tail). In the ovaries were found a number of small eggs. With this discovery

this ray falls into line with all other Beaufort forms known to the writer in being viviparous.

In July, 1908, the writer took at the Narrows of Newport River a brown ray whose length was 39 inches from the tip of nose to root of tail, the total length (the tail had plainly suffered amputation near the tip) 75 inches. Because of the presence of long horny prickles on the hinder part of the median line of the body and on the base of the tail, and of the structure and length of the tail, this ray was provisionally identified as *Dasyatis sabina*. This identification needs confirmation. The ray may have been *Dasyatis hastata* as above. No other specimen has since been seen.

Mobula ölfersi (Müller & Henle).
Small Devil-Fish.

Of all Coles' captures, however, none has aroused so much interest as that of the Mantid ray, *Mobula ölfersi*. This all at first mistook for *Manta birostris*. Coles brought to the laboratory, on the last day of the writer's stay at Beaufort in 1910, a head preserved in formalin. It was examined hastily and pronounced *Manta birostris*. So said all the other students of fishes to whom it was submitted. Mr. Coles, however, contended all the time that it was not *Manta*. At the meeting of the American Fisheries Society in New York, Sept. 27-29, 1910, 2 specimens, a male and a female, now in the American Museum, were submitted to the inspection of that Nestor among ichthyologists, Dr. Theodore Gill, who at once unhesitatingly said that they were not *Manta birostris*, and suggested that they were *Mobula ölfersi* as first described by Müller and Henle. This diagnosis was confirmed and they were so named in Coles' paper. This is indeed a great find. Jordan and Evermann say of the identical or closely related form, *Aodon hypostomus*, "This species, described from Jamica, is very imperfectly known, and may be the same as *Aodon ölfersi* (M. & H.), afterwards described from Brazil." Coles' specimens are the first taken in North American waters.

The teeth of *Mobula** are very small and somewhat shark-like

* The teeth of Coles' specimens have been studied and reported on by Pellegrin (1912). See literature cited.

and utterly negative the commonly accepted idea that the devil-fishes, as the Mantid rays are commonly called, live on shell-fish. Coles watched them fishing in small schools for minnows, using their cephalic fins to form funnels for scooping the minnows into their wide mouths. On dissection he found only small fishes in their stomachs.

Coles captured 9 of these rays in 1910 and saw a school variously estimated to contain 30 to 50. Their favorite sport consists in leaping into the air, and this of course makes it very hard to estimate the number in a school. None of these rays exceeded 5 feet in width. The color of the fresh specimens is black but after death this changes to a dark blue. The commonly accepted idea is that the horns of the Mantids are movable and that they are used to grasp objects and transfer these to their mouths. Coles by experiment proved that this is not true of *Mobula*. The horns have little if any movement but the cephalic fins, which are ordinarily carried tightly wrapped around the horns, may be distended and used as indicated above.

Coles had the good fortune to see these rays in sexual union, belly to belly, the female underneath on her back, her pectorals curved upward closely embracing the pectorals of the male which were also curved upward. Copulation lasted for some time but was not continuous, being interrupted by separations during which the fish leaped into the air or swam in graceful curves.

By an interesting coincidence, Coles first three captures of this ray in 1911 were made on the same days as those in 1910, viz., July 6, 7, and 8. On these days he took 7 specimens, 6 males and one female. No others were then seen in the bight of the Cape until the night of Aug. 3, when the fishermen reported a leaping devil-fish on the eastern side of the Cape breakers. Daylight found Coles on the spot where he saw one leap and a school pass under his boat. He surrounded this school in 10-foot water, and captured 7 specimens (1 male and 6 females) while one escaped over the cork-line and 2 under the lead-line.

Of the 14 specimens taken, Coles has retained 3 and has pre-

sented 4 to the United States National Museum, 2 to the American Museum of Natural History (in addition to the 2 sent in 1910), 2 to the British Museum (Natural History), 2 to Museum D'Histoire Naturelle, Paris, and one to the writer.

Jordan and Evermann (1896) say that the Mantid rays are ovoviparous, but Coles on July 14, 1911, brought to the writer at the Beaufort laboratory a preserved uterus with the attached ovary (together with a yellow yolk which had escaped during the operation of excision) taken from a female *Mobula* a week previous. The egg on examination unfortunately, as has often been the writer's experience in dealing with such, had lost its embryo. The greatly swollen uterus measured externally 8¼ inches around, and 10¾ long while the length of the tube connecting it with the cloaca was 3⅞ inches. The walls of the uterus at their thickest part measured ½, and at the thinnest ¼ inch, and were very villous, as much so as any other ray heretofore examined. The villi measured from ½ to ¾ of an inch long and the wall of the uterus to which they were attached was composed of long palisade-like structures of which they seemed to be outgrowths.

Ophichthus ocellatus (LeSueur).

Spotted Snake Eel.

The first reported capture of this eel in North Carolina waters was that by Coles at Cape Lookout in April of the year 1910 while down on a short expedition. He reports that this fish has the interesting habit of swimming or rather drifting in a vertical position. So far as the writer knows this West Indian eel has never before been caught north of Florida.

Lycodontis moringa (Cuvier).

Common Spotted Moray; Hamlet.

The first moray ever recorded at Beaufort was *Lycodontis ocellatus* taken off the inner north-west corner of Bird Shoal in eel-grass by George Bean and the writer on August 20, 1903. Another one was caught by other parties the following year. Since this latter time no moray had been taken in Beaufort waters until July, 1911, when Coles procured a small one from

a bed of eel-grass in Bogue Sound near Morehead City. It was presented by him to the U. S. National Museum and identified by Mr. Bean as *Lycodontis moringa,* a West Indian eel, not only new to North Carolina but not before taken so far north.

Polydactylus octonemus (Girard).

Threadfin.

Another fish heretofore unknown in our waters, which Coles had the good fortune to add to our ichthyological fauna, is the threadfin, *Polydactylus octonemus.* While this fish, according to Jordan and Evermann, (1896) is known to occur on sandy shores along the Atlantic Coast as far north as New York, it is nevertheless an extremely rare fish. Coles took his specimen at Cape Lookout in July, 1910.

Monacanthus ciliatus (Mitchill).

Leather-fish.

While 3 species of the family Monacanthidæ have been taken at Beaufort, namely *Monacanthus hispidus, Ceratacanthus schoepfii* and *C. punctatus, Monacanthus ciliatus* is now recorded for the first time. In July, 1911, Coles took a small specimen about 3 inches long in company with *M. hispidus* in the bight of Cape Lookout. This is a form common in Florida, but, so far as the writer knows, it has not been taken so high up the coast before.

Lactophrys tricornis (Linnaeus).

Cow-fish; Trunk-fish.

Of the 2 trunk-fishes recorded for Beaufort, *Lactophrys trigonus, and L. triqueter,* the writer collected a specimen of the latter in 1902 and for some weeks kept it as an aquarium pet. As such it was a very unique and interesting specimen, especially so in its feeding. In July, 1911, Mr. Coles, by taking 2 specimens about 4 inches long, added *Lactophrys tricornis* to our local fauna, and in so doing has verified Dr. Smith's prediction (page 344) that it "will no doubt in time be detected on the North Carolina coast." These specimens are on deposit in the National and American Museums.

Lyosphaera globosa Evermann and Kendall.

This fish, heretofore recorded from the mouth of the Rappahannock River in Chesapeake Bay and from Biscayne Bay, Florida, is now to be catalogued from an intermediate point since Coles took two small ones in eel-grass at Cape Lookout in July, 1911. His specimens, about the size of a man's thumb, were kept for a half day in a bucket of salt water. He noted that they are poor swimmers since they retain their globular form while swimming.

Gobius glaucofrænum (Gill).

Another fish new to the fauna of North Carolina is *Gobius glaucofraenum,* which Coles took in 1911 in eel-grass in the bight of Cape Lookout. His specimen, which is now in the American Museum, is small and is presumably the first ever taken north of the Florida Keys.

Porichthys porissimus (Cuvier & Valenciennes).

Bagre Sapo.

The last (14th) fish, which by the indefatigable energy of Mr. Coles, has been added to the ichthyological fauna of North Carolina, is the interesting toad-fish, *Porichthys porissimus.* This fine 8 or 9 inch specimen was taken at Wreck Point in the bight of Cape Lookout early in July, 1911. Heretofore, so far as the writer is informed, this southern form has not been taken north of the South Carolina coast.

SPECIES RARE ON THE NORTH CAROLINA COAST.

In addition to these new species, Coles caught a number of fishes not now in the Beaufort collection or at any rate but little known, and it does not seem out of place to list them here that record may be made of their occurrence in North Carolina waters. Some of these are described in his paper elsewhere referred to, but the data concerning the greater number were communicated to the writer by Mr. Coles personally.

Sphyrna zygæna (Linnaeus).

Hammer-head Shark.

The writer (1907) has described the capture and given full and careful measurements of a female hammer-head Shark, *Sphyrna zygaena,* 12 feet 6 inches long. This has for some years remained the record shark in the Beaufort region not merely for hammerheads but for all species. A new record however was established during 1910 by Coles' capture of a hammer-head 14 feet 3 inches long. This was also a female which while being hauled up gave birth to 5 young averaging 29 inches in length. That this fish is more plentiful than is commonly thought is attested by the fact that during June and July, 1910, the writer took more than a dozen young ones averaging 18 to 24 inches long at various fishing grounds in Newport River. Fewer were taken in 1911.

Squatina squatina (Linnaeus).

Angel-fish; Monk-fish.

The only published record of the capture of this curious shark is by Smith in his Fishes of North Carolina (1907). This was in April, 1904, while in the same month in 1910 Coles took another at the same place, Cape Lookout. He reports that several were taken there in 1911.

Raja eglanteria Bosc.

Clear-nose; Brier Ray.

The present writer has elsewhere (1910) recorded the finding of a dead and half dried specimen of the clear-nose ray, on Fort Macon Beach and its deposit in the museum of the laboratory. Dr. Smith (1907) writes that he saw numerous rays of this species on the beach at Cape Lookout in April, 1904. Coles says that he found them abundant there in April, 1910, but saw none in July. From this we may conclude that they are possibly only winter migrants to our coast.

Albula vulpes (Linnaeus).

Lady-fish; Wolf-fish.

The lady-fish, or wolf-fish, *Albula vulpes,* has been recorded from Beaufort by Yarrow (1877), but has not since been taken

until Coles caught one at Cape Lookout in July, 1910, the only one in 9 years' fishing there. The food value of this clupeoid is slight because of the great number of its bones.

Athlennes hians (Cuvier and Valenciennes).

Gar-fish.

The flat-sided gar is comparatively rare, none being recorded at Beaufort between 1885 and 1905, probably because they are ordinarily confounded with other gars, especially *Tylosurus marinus.* In this later year quite a number were taken. Coles caught several at Cape Lookout during 1910, and a number in 1911.

Auxis thazard Lacepede.

Frigate Mackerel.

This frigate mackerel has been only sparingly reported from Beaufort being called "bonito" and not carefully distinguished from the fish properly so-named. Coles reports large schools of them at Cape Lookout in July, 1909, and 1910, but none were found in 1911.

Sarda sarda (Bloch).

Bonito.

The bonito is not very uncommon at Beaufort, but does not reach the size attained elsewhere. Smith (1907) gives its average weight as 5 to 6 pounds, and that of the largest hitherto recorded at 12 pounds. Coles, however, reports the capture of several at the Cape in 1910 weighing slightly over 25 pounds each. He caught only a few in 1911, and these of smaller size.

Oligoplites saurus (Bloch and Schneider).

Leather-jacket.

The leather-jacket has been recorded from Beaufort but one time despite the fact that it has been taken as far north as New York. According to Dr. Smith, on May 17, 1904, a fisherman brought a 10 inch specimen to the Beaufort laboratory. Late in June, 1911, Coles collected a 10-inch specimen at Cape Lookout.

Seriola lalandi (Cuvier and Valenciennes).

Amber-fish.

According to Smith (1907, p. 203), "There appear to be no published records of its capture in North Carolina, but it undoubtedly occurs there every year and could be found if sought for with proper apparatus on the outer shores." This prophecy was verified by Coles, who, at Cape Lookout in July, 1910, took several specimens.

Caranx bartholomæi (Cuvier and Valenciennes).

Yellow Jack.

Of the genus Caranx, Coles took the following species in July, 1910, *bartolomaei, crysos,* and *latus.* Of the former but one specimen has been taken at the laboratory since 1885, and that in August, 1905. Of the second and third a number have been taken of late years, mainly in the pound net operated by the laboratory. In 1911, Coles collected and forwarded to the American Museum several specimens of *C. bartholomaei.*

Vomer setipinnis (Mitchill).

Horse-fish.

The horse-fish, while not rare at Beaufort, is so far as is known not taken in any quantity, hence it is somewhat surprising to read that in July, 1910, Coles took about 100 pounds of this fish at the Cape in a single haul. He reports it as excellent eating.

Chloroscombrus chrysurus (Linnaeus).

Bumper.

Of the related *Chloroscombrus chrysurus* but few captures are noted on the laboratory cards and these at wide intervals. However, Coles found them in fairly large numbers at Cape Lookout in July, 1910, and again in 1911.

Trachinotus glaucus (Bloch).

Gaff-topsail Pompano.

The gaff-topsail pompano is at present a rare fish at Beaufort, although it is reported to have been fairly abundant some 15 years ago. In 1903 a 9-inch specimen was taken, and in

July, 1911 Coles took a number of young while seining for blue-fish at Cape Lookout.

Trachinotus falcatus (Linnaeus).

Round Pompano.

Only young specimens of the round pompano seem to have been taken at Beaufort. Likewise Coles' specimens collected at Cape Lookout in July 1911 were young. They were taken in company with *T. glaucus* and *T. carolinus.*

Lutianus griseus (Linnaeus).

Gray Snapper; Mangrove Snapper.

Our only record of this West Indian snapper is contained in Smith's Fishes (p. 287) where it is stated that 4 small specimens were seined in Beaufort harbor in 1902. Coles' capture of one small specimen in eel-grass at Cape Lookout in July, 1911 will constitute a second record.

Haemulon plumieri (Lacepede).

Black Grunt.

Heretofore the "snapper banks" off Cape Fear have been constituted the northern limit of the black grunt, *Haemulon plumieri.* This however must now be moved to the "rocks" of New River Inlet, since Coles finds them there in great numbers. He caught them running up to 1½ pounds in weight in 1911.

Bathystoma rimator (Jordan and Swain).

Tom Tate; Red-mouthed Grunt.

The Cape Fear "banks" have also been heretofore the northern limit for the adult "tom-tate grunt", but Mr. Coles found them likewise common at the New River Inlet "rocks" in 1911. However they are small, averaging less than ½ pound in weight. At Beaufort numbers of young have been taken but no adults.

Otrynter caprinus (Bean).

Long-spined Porgy.

This porgy was not known at Beaufort prior to 1904 when a number were taken in the laboratory pound net. In 9 years'

fishing at Cape Lookout, Coles has caught but 7, 6 of which were taken in 1910 and one in 1911.

Cynoscion nothus (Holbrook).

Silver Squeteague.

While the gray and spotted sea trouts, *Cynoscion regalis* and *nebulosus,* are among the most common and valuable food fishes at Beaufort, the rare form *C. nothus,* the silver squeteague, is known from but one specimen taken just outside the Inlet in 1899. Coles, however, took one at New River Inlet in January and another at the Cape in April, 1910, and in 1911 at the same place a young one which he presented to the United States National Museum. It seems to be either a solitary fish or else a straggler in the Beaufort region.

Larimus fasciatus (Holbrook).

Banded Drum.

The banded drum is a fish so little known at Beaufort that its capture at Cape Lookout by Coles in 1910 seems worthy of record. Only a few were taken in this year, but in 1911 Mr. Coles relates that he made a catch of such size that his net threatened to break. Although it was "backed" from around the school, even then it took hours to clear it of the gilled fish. A number of these were sent to the National Museum.

Iridio bivittatus (Bloch).

Slippery Dick.

This beautiful little tropical fish is seldom taken at Beaufort, in fact the specimens dredged by the steamer Fish-Hawk in 1902 are the last recorded until Coles collected several in July, 1910, in eel-grass growing in shallow water in the bight of the Cape. He writes that the name is well bestowed, the little fish being harder to hold than a small eel would be. None were taken in 1911.

Prionotus evolans (Linnaeus).

Striped Sea-robin.

This interesting gurnard has not been taken at Beaufort in over 25 years though it is known only from the coast of the

Carolinas. However, at Cape Lookout Coles captured a dozen specimens during July, 1910. These are all deposited in the American Museum of Natural History. A few were taken in 1911.

Astroscopus y-græcum (Cuvier and Valenciennes).
Electric Star-gazer.

The electric star-gazer, the "electric toad" of the fishermen, is occasionally taken at Beaufort and the laboratory museum has several specimens. None however reach the size of the 15-inch individual taken with the spear by Coles in July, 1910. Two other small ones were also captured by him. The present writer on July 14, 1904, in the inner harbor at Beaufort collected a young one only 2½ inches long. This was much darker in color than the adults and lacked the spots.

The writer has seen the star-gazer, by convulsive movements of its body, bury itself in the sand at the bottom of an aquarium until only its mouth and eyes were visible. The water pumped through the mouth and over the gills escaped on each side through a conical depression in the sand above the hinder edge of each opercle. Since the fish lie thus imbedded in the sand, the lead lines of the seines pass over them readily and few are taken. Consequently but little idea of their relative abundance can be formed.

The electric organs are in the head back of and between the eyes. These are said to give shocks more powerful in proportion to their size than those of any other electric fish, but Coles reports that he found their power much weaker than that of the corresponding organs of *Narcine brasiliensis.*

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RECENT VIEWS ON THE CHEMISTRY OF DIET*

By Isaac F. Harris

Under the subject of diet we include all chemical substances which have to do with the nutrition of man. Hall has defined it as the physiological process of supplying the material needs of the body. In a broad sense, it means food, drink and oxygenation. A mixed diet consists of non-diffusible proteins, carbo-hydrates and fats, and the function of the digestive process is to break up these complex molecules into smaller, simpler, soluble and diffusible ones, which are capable of absorption and utilization by the body processes. The science of dietics involves the knowledge of the chemical composition of the human body and of the foods with which it is proposed to maintain and repair it, and the sequence of chemical changes which the body undergoes during the multiple processes of digestion and assimilation.

The nutrition of man is comparable to the fertilization of a vegatable form. In the latter case we first observe the chemical make-up of the plant and then look for a fertilizing material which will best supply these elements. If the plant has a high content of potassium, like the tubers, then we supply potassium to the soil. If the case in point be man, with a high content of nitrogenous, albumin-like tissue, then we must supply nitrogen in the diet. Furthermore, the supply of chemical elements in the food must be in such combination or molecular arrangement as to be available to the metabolic processes of the individual to be fed. While plant life in general can derive its nitrogen supply from the inorganic nitrates of the soil, man can obtain his nitrogen requirement from protein or albumin-like sources, only. McCollum says regarding a mixed, balanced diet, "Unquestionably the physiological value of a ration is largely dependent upon its chemical constituents, but the usual determinations made on feeding materials do not reveal the character or manner of combination of many of the constituents.

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*Read before the Jenkins Medical Association, Yonkers, N. Y., December 12th, 1912.

Consequently, the physiological value can be determined in the present state of our knowledge only by long continued observations of the reactions of the feed on animals."

In designing a complete ration for man one finds that the food elements fall naturally into three great groups, or classes: The proteins, carbo-hydrates and fats, and inseparably associated with them, the inorganic salts or ash of the food. Of these various constituents, the only dispensible one is the fats. One cannot indefinitely omit the carbo-hydrates portion without serious pathological consequences, and, eventually, death. Though the fats are a normal and important portion of the daily food intake of all classes of men, they are, theoretically, dispensible and practically, can be less regarded than any other constituent. As regards the mineral portion, or the inorganic elements, there are certain chemical elements like sodium, potassium, chlorine, sulphuric acid, the phosphates, etc., which could be considerably reduced, but as a whole class of bodies they are fundamentally and absolutely indispensable.

Generally speaking, there are as many dietaries as there are kinds and races of men. For example: There is the diet of the Japanese coolie, the peasant of Europe, the soldiers of the various armies, the American college man, the American athletes, European and American vegetarians, California fruitarians, *et cetra,* to infinity. All are living, all are active and healthy, and no one of them has fallen into any special classification of greater activity of mind or body, nor of greater life period. Each of these classes has been the subject of special study during long periods and more or less standards of diet have been the results. The standards of the various armies and classes of people of the world, have contained a fuel value ranging from 3000 to 5000 calories, and a protein allotment of from 30 to 180 grams, daily. Dr. Arnold, in his recent Atlantic City address, suggested the establishment of four standard diets for hospitals. He recommended the proportion of 100 grams protein, 80 grams fats and 300 grams of carbo-hydrates, and that these be arranged in such quantity

that diets Nos. 1, 2, 3 and 4 should contain 1500, 2000, 2500 and 3000 calories, respectively. Personally, I would think his protein per cent. for a sick man very high. However, this is a matter of opinion, after all, and depends altogether upon what is indicated. Of all the conspicuous and far reaching dietaries of this kind, the most recent were, probably, those of Professor Chittenden and associates, at Yale, upon United States soldiers. These men were under military discipline all the while, and their diet and activity were capable of accurate measurement during a relatively long period. The results of these experiments, familiar to you all, was to lower the protein standard or requirement to about 40 to 50 grams, per day, or, one-third the usual practice for an average healthy man performing a normal daily routine of active life. The protein part of the diet has always been the subject of chief interest on account of its great complexity and its relation to the repair of tissue wastes and the association of its end-products of digestion with pathological conditions.

It has been very valuable to establish upon an experimental basis these various standards of the past. However, they must be looked upon as maximum and minimum guides between which we may select with discretion and not as rules to follow. There can be no satisfactory diet for all classes of men or any individual for all time. No two of us will get the same results from a fixed diet, neither will any one of us continue indefinitely to derive the same results from a fixed diet for all times of life. You have doubtless been asked many times, "Doctor, what shall I eat?" If you take it seriously, it is one of the hardest questions you receive in your practice and calls for many in return from you. You must first know the conditions for which you are to prescribe. It all depends upon the age, bodily activity, health, environment of climate, state of mind, etc., and, last of all, what you can find out about the personal idiosyncracies. It may be reasonable for you to inquire in return, "Are your habits, proportions and physiological processes normal, in your best knowledge?" "Do you suffer from anemia, or surplus

adipose?" "Are you worried or happy?" "Married or single?" "How is your peristaltic wave?" "Is your indican high?" "What are your bacterial flora?" "Is the alcoholic proportion of your diet excessive?" "What is your average opsonic index?" "Do you 'Fletcherize' or bolt your food?" "Are you a commuter?" These questions may seem slightly fanciful, but each and every one has a relation to what the ration should be and the fate of such food products in the twelve yards of the digestive tract. More seriously, Dr. Benedict, in his recent studies of metabolism of man has said, "When we consider the chemical complexity of man's organism, the considerable differences in size, weight and temperament and the marked changes in diet and physical activity in the course of his daily life, it is difficult to imagine him having a normal metabolism to which all metabolism measurements can be referred. No two people may be said to be alike, even in physical appearance, and it is reasonable to suppose that when all the factors of life are taken into consideration this lack of similarity will be even more apparent. Different people, would, therefore, be expected, a priori, to show marked differences in metabolism, and yet the collection of statistics regarding the metabolic functions of individuals approximating uniformity in size, weight, physical activity and general development will give results of distinct value and interest." Observation of the results of Benedict in the experiments of metabolism of man by the calorimeter method shows what a wide range of conditions the dietitian has to deal with.

There cannot be, of course, a fixed standard of food in regard to either calorific or tissue-building functions without noting all the data and specific idiosyncracies of the individual under consideration. However, general laws may be laid down under specific conditions of age, body weight, etc., as constants, which may be applicable to new individual cases with remarkable physiological accuracy. Benedict, in a striking series of experiments has demonstrated very clearly that a change from a diet poor in carbo-hydrates to one rich in carbo-hydrate is accompanied by a considerable retention of water by the tissues

of the body. Conversely, he has shown that when a change is made from the rich carbo-hydrate diet and a fat diet is substituted, there is a considerable *loss* of water to the body. It is obvious, therefore, that if a change is made from a normal diet to one containing an excessive proportion of carbo-hydrates, even though the total nutrients in the food may be insufficient for the maintenance of the body, the excess carbo-hydrates may cause the retention of a sufficient amount of water to more than make up for the loss in the body material resulting from the decrease in the total body food supply.

A typical experiment follows: Diet for three days largely carbo-hydrate, suddenly changed to one of equivalent energy, which, however, was derived in large part from fat. The changes in body weight during the series was remarkable and interesting. During the three days carbo-hydrate period, there was a total *gain* of 61 grams (2 ounces). On the fourth day the diet was so changed that the greater part of the energy came from the fat rather than from the carbo-hydrates. Although the total amount of food and drink ingested during the fat period was somewhat greater, there was a very material *loss* to the body, averaging 914 grams (30 ounces) per day. The gain and loss above had to do with *water only*. Benedict says this rapid loss of water under specific diet should be interesting to continue with various inorganic salts and is significant in such pathological conditions as dropsy. What factors in the diet determine the gain of water are of great importance.

Generally speaking, it matters not what the source of the carbo-hydrate may be. Of course, we must recognize the fact that the new starches, surrounded by a mass of indigestible tissue, is the most of all likely to escape the digestive juices, and, therefore, the one which is liable to pass through the body unused to the greatest extent; that is, considering that the raw starch must be disintegrated and prepared for digestion by the grinding action of the teeth during an era of rush and bolting of food, it is very probable that much of it will escape grinding and imbedded in the sur-

rounding tissue of indigestible cellulose, will escape conversion into soluble food products. Therefore, if the starch be fed wholly uncooked it must be allowed more freely in the diet because a greater part will never become available as food material. This is strikingly shown in a vegetarian or fruitarian diet where the uncooked carbo-hydrate proportion is allowed in such quantities. To offset this condition we must bear in mind that this kind of starch or carbo-hydrate food will assist in filling the intestine with an indigestible mass of fibre which plays an important function in stimulating peristaltic action and giving character to the feces. If the carbo-hydrate be fed in the form of cooked starch, the hard granules have been ruptured and the first stage of starch digestion has begun. The swelling and hydration has taken place and a certain amount of soluble starch and dextrin have already been formed.

Such a carbo-hydrate mass is capable of very rapid conversion into soluble sugars under the influence of deliberate mastication in the presence of an active saliva. Those of us who have many times witnessed the action of such diastatic enzymes as ptyalin, pancreatic, lipase, or maltase upon a well cooked and partly dextrinized starch at body temperature have been impressed with the rapidity of this enzyme action in comparison with the slower action of pepsin and trypsin upon the proteins. It has been shown that the three pancreatic enzymes capable of digesting proteins, carbo-hydrates and fats are found in the intestine of the new-born infant from the very first. Therefore, we may expect a co-operation between the saliva and the pancreatic juice in the breaking up of starches, even in early life. Where it is of interest to spare the diastatic digestion any extra work, or where the individual does not "handle" his carbo-hydrate well, we naturally turn to the soluble sugars and it matters not greatly which one we may select. In some recent experimental work in animal feeding, lactose has indicated some superiority to the other sugars of the diet, but at present that information is incomplete and is not available.

Just what the amount of this carbo-hydrate portion should be, depends upon the proportion of protein and fats. You will recall

that the carbo-hydrate oxydizes in the body to form water and carbon dioxide, while the protein substances gives such end products as urea and uric acid. Therefore, the body has eventually from a high carbo-hydrate diet, simple chemical end-products, which are not associated with trouble in elimination. It is important to supply ample fuel value in readily digestible carbo-hydrate in order to spare the protein. It is more justifiable to deal out the carbo-hydrate in excess in the diet than any other constituent. It is "handled" by the body with the least effort and saves any protein which should go into forming new body tissues from having to act as a fuel on account of shortage elsewhere of either fat or carbo-hydrate. This sparing action of the carbo-hydrate upon the fuel protein or tissue protein is nowhere better shown than in the case of the Southern negro in the fields during the sugar cane season. He quite largely exists upon the thick syrup of the sugar cane, and naturally conserves in this way his limited amount of protein, and thus meets the "high cost of living."

Referring again to the fat portion, I may say that the theory of transmigration of fat globules seems untenable. There is great doubt if any neutral fat passes to epithelial cells of the intestines as such. It must be split up by the combined action of the alkaline pancreatic juice and bile into its simpler constituents, the fatty acids and glycerine. To be sure, the fat soluble dyes, such as Sudan 3 and Biebrich Scarlet, when fed dissolved in such fat as olive oil, do appear in the laid-on adipose tissue and in the lipoid layers in the yolk of the egg. But this does not prove the transmigration of neutral, undigested fat, which may be explained by the absorbtive action of the circulating bile upon the split fatty acids and dye at the same time. In other words, the transport of fat-soluble dye may be done by the bile and finally deposited with the adipose tissue, where we find it in post-mortem. If glycerine and fatty acids are fed, fat will be formed and deposited the same as from a diet of neutral fat. Also, if the soaps of the fatty acids are fed the corresponding fats will be deposited. Furthermore, if fatty acids alone are fed, fat will

be formed and deposited just the same as on a diet of neutral fat. In other words, during a fat-free diet containing the fatty acid radicals only, the corresponding fats will appear in the intestinal epithelial cells all the while, showing that the body has the power of immediately synthesizing the glycerine and combining the two to form a circulating fat. Not only has the body the power of synthesizing the glycerol portion, but also the fatty acid radicle. In summary, it can synthesize its own fat from other non-fat constituents or "building stones" of the diet. Long time experiments with chemically fat-free rations show an increase maintenance of body fat tissue. Besides, we have the old well-used example of the milk and butter fat production in large quantity on a practically fat-free diet, that is, from a largely carbo-hydrate and protein diet, where the intake of fat elements is very far out of proportion to the fat production and secretion.

Are the proteins, carbo-hydrates and fats of the diet specific for the synthesis of specific tissue? No. Does it require absolutely and exclusively the casein and lactalbumin of mother's milk to produce the infant tissue and infant metabolic exchanges? No. Does it require the Gliadin and associated proteins of the endospern of the wheat kernel to produce the wheat plantlet? We do not know. And why did Nature "happen" to place a crystalline albumin in the egg and the protein edestin in the kernel of the hemp seed? Ten years ago I recall hearing my associate and teacher, Dr. Thomas B. Osborne, of New Haven, say: "Suppose the reserve proteins are specific for each biological kind. What would happen if we could aseptically replace the albumin of the egg with the protein gliadin of the wheat and incubate the resulting product? Would we produce a chick of normal proportions, or would he take on vegetative characteristics, develop chlorophyl, multiple wings, and keep cool in summer under the shade of his own green leaves?" Of course, this was an indulgence of the imagination to the production of a monstrosity.

But, seriously again, we are just now in the dawn of a newer and broader chemistry whereby some of

these complicated processes associated with the intricate protein molecules are beginning to clear up. It has been the good fortune of Dr. Osborne, whom I mentioned above, to play a leading part in the solution of these problems. Quite within this decade the protein molecule has begun to yield its great store of secrets and we are now in possession of practically all the decomposition products of the most familiar proteins and the gross molecular composition of the most important constituent of the dietary is quite well known. The average protein has a molecular weight of approximately 2000, and consists of practically 24 distinct chemical substances, linked together to form the complete protein. The simplest protein molecule consists of about 15 distinct and different amino acids and about three more basic substances, and when the protein material is such a one as nucleoprotein, it contains phosphorus in that complicated organic body, nucleic acid. Then the chemistry of it becomes even more complicated, though the composition of the nucleic acids also is quite well understood today.

It is through just such careful feeding experiments as those conducter by Osborne and Mendel today that these questions of specificity of the diet are being answered. Such feedings for long periods on a single protein substance, while all other constituents of the diet are satisfied, has shown for long time that when that protein substance is gelatine, wheat gliadin, zein from the maize, etc., that the animal cannot live beyond a reasonable wasting period. Why? Because those proteins do not contain all the elements necessary for tissue synthesis. Gelatin or wheat gliadin have little or no tryptophane, little glycocoll, and are short in other respects of certain food groups which the body must get from the alimentation to manufacture blood serum-albumin, muscle-myosin, hematin, haemoglobin and the like tissues of the body. It is simply a problem of chemical construction. The building materials must be supplied. If you wish to build a brick house you buy brick, lime, sand and water. Therefore, if you wish to build a human body, you must supply the chemical building stones or "Bausteine."

In regard to the proteins, they are apparently not strictly spe-

cific, but are to a degree. Only recently experimental animals have been nourished into the second and third generation upon a rounded diet containing a single protein. But, that protein had to be relatively complete in its chemical make-up. In the present state of our knowledge in regard to the protein portion of the diet, it is well to select a variety so that we may be reasonably sure to include all the chemical groups or "Bausteine," which must be present in the nitrogenous part of the food.

Regarding the specificity of the carbo-hydrates, they are of a much simpler composition, are only one substance and may be looked upon chiefly as a carbonaceous fuel for the great metabolic furnace. In a normal individual the carbo-hydrate portion of the ration is soon converted into the dextrose or circulating sugar which is readily oxidized to carbon dioxide and water. It matters not whether that carbo-hydrate is a soluble starch or a soluble sugar, the processes of a normal digestion can handle it. Of course, we are assuming that the carbo-hydrate in question is a common food starch or sugar and not a complicated cellulose of indigestible structure and composition, such as the algæ, wheat straw or hay. Bear in mind, at this point, we are only bringing out the point of specificity of the various elements of the diet, and the carbo-hydrates are not such. The whole carbohydrate, from a pure dietary standpoint, may be lactose or cane sugar through the whole of a long life time with perfect nutritive results.

How about the fats? Are they specific for specific adipose tissue formation? No, they are not. We are quite positive about this matter recently. This may be modified by abnormalities, but under the well and healthy conditions of the oxidative, fermentative and absorbtive processes of the body, any suitable fat may be fed, and may be fed continuously. Why? What is the function of it? It is first, a great fuel food of twice the calorific value of carbo-hydrate and twice that of the protein. Then, it acts to spare the protein oxydation and takes the place of the carbo-hydrate when it is not sufficient calorific amount. Possibly the hyrolytic products of fat digestion, glycerine and the corresponding fatty acids, leads to a

more ready formation of the fatty tissues of the body than were they not supplied. However, we know recently that the fat of the body surplus may be synthesized from the carbo-hydrate or protein of the diet and, further than that, we have animal experiments where they have been fed into the second generation and have given milk to their young on a fat-free diet. When the fat is omitted from the dietary, the corresponding calories must be supplied by the carbo-hydrate in order to spare the protein.

In the summary, the proteins are to a slight degree, specific foods, but the carbo-hydrates and fats are not at all so. Regarding protein specificially: Osborne and Mendel say today, "Whatever may be the source or chemical make-up of the protein previous to its involvement in the nutritive processes, the resulting tissue cells and fluids remain characteristic and specific for the species."

It is well known that by limiting the food supply of an ungrown individual, its development may be retarded. If the underfeeding is prolonged through the cycle of growth, the full stature limited by heredity may not be attained. The Sub-normal growth of immature animals on such a typical experiment as wheat-gliadin—stunting of albino rats suggests a chemical explanation of beneficial effects observed from a "change of environment, vacation, country air, mineral springs, and the like" when the individual in his or her daily routine at home, may have been suffering from a deficiency of some special chemical element or group, which he required in greater amount. These specific substances which we do not always get in sufficient quantity are typified in iodine and its relation to the thyroid, growth and control; and a phosphorus deficiency, as shown in beri-beri. Certain individuals have wasteful idiosyncracies, whereby they do not conserve all the chemical elements and groups which reach the ailmentary tract in the food, and, consequently, they must be fed these same substances in greater quantity or in more assimilable form. McCrudden, (Rockefeller Institute) has recently shown that in certain cases of retarded growth there is faulty skeletal

development and disturbance of calcium metabolism. The bones are frail and easily fractured. Large quantities of calcium are lost through the feces, while the urine is almost free from calcium. He says it seems possible that the retarded skeletal development is due to the lack of calcium salts available for bone growth. Likewise, most of us receive sufficient metallic iron in our dietary, but if abnormal amounts are discarded in the intestinal waste, symptoms of anemia may follow and assimilable iron feeding may be indicated.

I have discussed the minimum protein of the diet, but what of excessive amounts? One interesting observation is the relation of forced feeding (by this I mean excessive feeding) to the content of inorganic salts. Quoting Osborne and Mendel again, "In forced protein and forced fat feeding, we must look out for the inorganic bases, or the acid digestion products of the food will drain the skeleton of sodium, potassium, magnesium and like bases, and the net result may be a gain in adipose and muscular tissue at a sacrifice of skeleton. This is particularly the result of the acid end-products of the carbo-hydrate portion. You recall a typical abnormal illustration of this type in acid or Ketonuria, associated with sugar combustion. Such individuals must have the common bases to neutralize these acid products or the sacrifice of these elements by the body must follow.

Just at this point I feel justified in a few remarks regarding bacterial flora. Though bacteriological, it cannot be omitted from dietary studies any longer. The organisms common to the intestinal tract when feeding upon a rich protein diet produce basic or alkaline end-products, while on a carbo-hydrate surplus the local conditions become acid. Whether this chemical condition be alkaline or acid determines to a large extent the permanent bacterial flora. Quoting Kendall: "A most fundamental principle of bacterial metabolism may be expressed thus: Fermentation takes precedence over putrefaction." That is to say, bacteria in general which can use both carbo-hydrate and protein act upon the former in preference to the latter, though both are present in the same food. It must be remembered that all true toxins are nitrogenous, while acids

as produced by fermentation are at worst but irritants and are for the most part non-nitrogenous. It would appear, therefore, that the production of toxic substances of bacterial origin must be the result of proteolytic putrefactive activity rather than of fermentative activity.

The importance of the saving action of carbo-hydrate for protein in the light of toxin production must be apparent. In this connection again, Osborne and Mendel have attributed great importance to the bacterial flora in their success in maintaining animals on what we might call insufficient food. In the first place, they have reported what has many times been observed, i. e., that their caged animals, living on an artificial and under-nourishing diet, will eat of their own feces. Furthermore, they report the interesting observation that their animals fed on a stunting diet, will eat the feces of other rats rather than their own, when the opportunity is offered. In a number of such cases, they have observed an immediate improvement in the rate of growth, while the diet remained constant. This gain in utilization of the food, they have attributed in such cases to a new acquisition of bacteria. By way of illustration: Their maintenance diets for the albino rats, were purine-free and they advance the hypothesis that probably the bacterial flora played an important part in such synthesis as the purines. Quoting Herter: "The number of bacteria in the daily excreta of man has been estimated as approximately 126 billion." Such an amount of bacterial activity cannot be overlooked in the chemical production or synthesis of definite compounds. Osborne and Mendel suggest that probably the bacteria are able to synthesize some of these necessary compounds which, without them, would be unavailable for epithelial absorbtion. In other words, when the animal under dietary study is observed to exist on a purine and lipoid-free diet, possibly those substances become available for absorbtion in the intestinal tract from the disintegration of bacterial bodies. McCollum has recently demonstrated the long maintenance of hens on a chemically fat-free and lipoid-free diet. Under these conditions, pounds of eggs, during successive weeks, were

collected with the normal content of lecithin and fats in the yolks. Was that due to bacterial flora or can the hen synthesize lecithin? Another interesting aspect of the widely recognized importance of the bacterial flora has been the mushroom-like growth of the ideas of Metchinkoff and Massol upon the lactic acid bacillus and cultures.

The fundamental principles of fighting one bacterium with another harmless culture and the resulting cleansing of the intestinal tract of putrefactive, poisonous, substances is to you a familiar problem. Quoting Herter again: "The work of Baumann and others has taught us that although the putrefactive decomposition of the protein in the intestine is a consequence of micro-organisms which regularly inhabit the gut, this decomposition often exceeds the limits of health."

In dealing with these putrefactive conditions we have various methods at our disposal. Besides the cleansing of the intestinal tract with acid-producing cultures, we have the wide variety of medicinal laxatives and antiseptic drugs. There is one other more recent method to which I would call your attention. In cases of intestinal activity caused by a too high purity of food intake, possibly with too little indigestible fibrous material, or from sluggish peristalsis, or any other cause, the result is the condition of common constipation which means a chapter of typical toxic conditions, most of which can be readily produced experimentally by doses per os of the products of protein putrefaction, that is, indol, skatol, putrescine, phenol, kresol, etc. It has become a rather recent practice to feed to such individuals the polysaccharide, hemicellulose, agar agar, to produce filling of the gut, or what is called in feeding experiments, "roughage." This is supposed to act by hydrating to an enormous degree and bringing about a stimulation of peristaltic movements.

I have been particularly interested in these properties of agar agar because a great deal of the original and best work on the indigestibility of this and other related marine forms has been done at the Yale Physicological Labo-

ratories, and part of it was in progress while I was there. It was a common sight in those days to see the Japanese investigator, T. Saiki, eating great hands full of these dry celluloses, without accompaniment. His published results are doubtless familiar to you. In conducting some of these experiments upon myself during recent weeks, I happened to observe that my formerly always low indican coefficient was now alarmingly high. Naturally I looked for the cause, and think I have found it in the agar feeding. On discontinuing the agar agar my indicanuria dropped. On taking up the diet again it recurred. Furthermore, I have confirmed this fact with a half dozen to a dozen cases. Though this is not a large number I am convinced of the observation because I have had a hundred per cent. positive results. I am giving you this as a new set of facts. It is to me extremely interesting that a substance that has been fed for the purpose of removal of putrefactive products has caused a high absorbtion of the chief of these, indol. I wish you to regard this as a preliminary statement, only. I cannot explain it yet.

I have here for your interest a set of indican tubes taken from a typical case such as I have mentioned. The tubes begin with normal days and end with normal days, including in the series one or two days following only one day of feeding ten grams of agar agar with a common breakfast cereal and milk. I might say that I have in progress a set of experiments to show the effect of feeding various agar preparations and "agar bread." The absorbtion of indoxyl has always been prompt and its elimination equally so. Certain cases, however, have led me to expect that the condition of indicanuria may persist for many days. I solicit your criticisms, suggestions and explanations of this phenomenon.

There is yet another relationship between the protein of the diet and indicanuria to which I would call your attention. Aside from all other considerations, the formation of indol must come from the protein. Several years ago, Dr. Osborne and myself have shown that certain proteins, like gliadin, do not give the tryptophane reaction. That is, they do not contain it, or only in

traces. Underhill has shown that tryptophane is the direct precursor of indol or indican in the urine. Furthermore he has demonstrated, experimentally, that the output of indican in the urine falls immediately, when the individual is fed on a tryptophane-free protein exclusively. When the individual was returned to a meat diet, the increase in indol formation promptly appeared. This is suggestive in the treatment of excessive putrefaction cases, where the practice is often to reduce the protein of the diet to a partial starvation basis. Why starve the body cells of all the food constituents of the protein molecule when only one is the offender? Why not increase the protein intake with gliadin, gelatine or Zein?

In conclusion, each constituent of the diet performs its specific function and must be seriously considered. The carbohydrates are necessary. The fats are valuable. The inorganic salts are indispensable; but the newer advance in chemistry of the diet must come from the proteins.

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J. M. BELL, - A. H. PATTERSON

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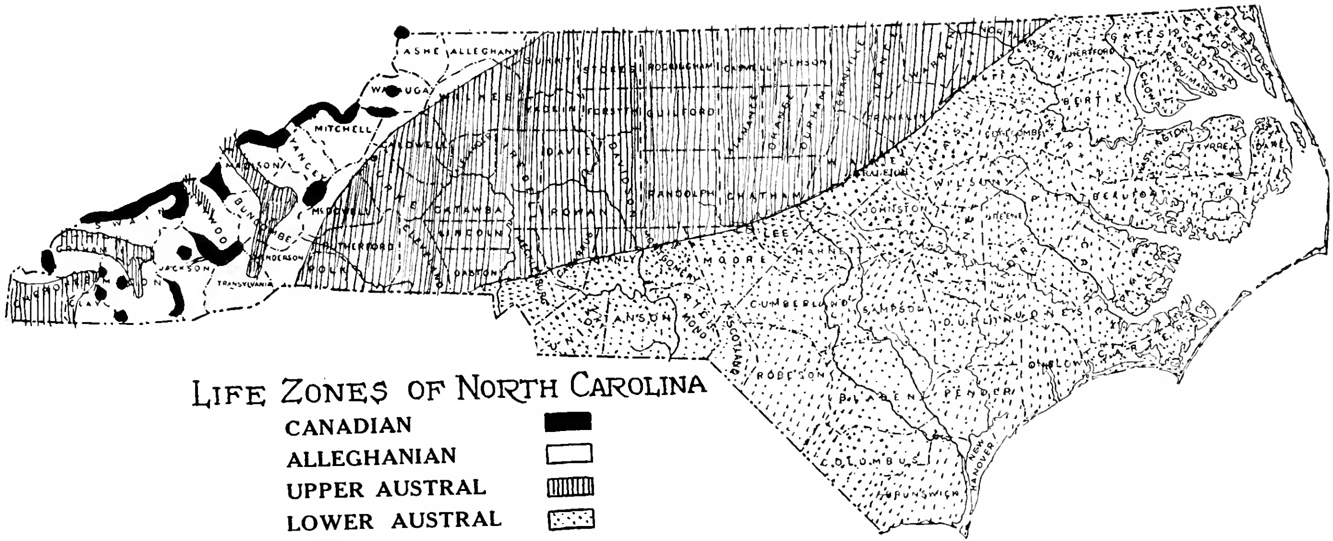

[Illustration to "Zoo-Geography," page 10]

JOURNAL
OF THE
ELISHA MITCHELL SCIENTIFIC SOCIETY

VOLUME XXIX JULY, 1913 No. 1

PROCEEDINGS OF THE TWELFTH ANNUAL MEETING OF THE NORTH CAROLINA ACADEMY OF SCIENCE HELD AT THE STATE NORMAL AND INDUSTRIAL COLLEGE, GREENSBORO, N. C., FRIDAY AND SATURDAY, APRIL 25-26, 1913.

The Executive Committee met at 2:40 P. M. Friday, April 26. There were present C. S. Brimley, President, and E. W. Gudger, Secretary *ex officio,* and by appointment in the absence of the other regular members, Dr. H. V. Wilson and Prof. C. W. Edwards. The Secretary made his report as to the state of finances and membership which was referred to the academy. An invitation of the faculty of Trinity College, Durham, to hold the next annual meeting there, was accepted. The following were elected to membership:

Briggs, R. W., Professor of Engineering, Trinity College.
Cunningham, Bert, Instructor in Sciences, High School, Durham.
Dixon, Alfred A., Professor of Physics, Guilford College.
Downing, John S., Professor of Chemistry, Guilford College.
George, W. C., Instructor in Zoology, University of North Carolina.
Metcalf, C. L., State Department of Agriculture, Raleigh.
Radcliffe, Lewis, Director, Laboratory of United States Bureau of Fisheries, Beaufort.
Ragsdale, Virginia, Associate Professor of Mathematics, StateNormal College.
Rosenkrans, D. B., Instructor in Botany, Agriculture and Mechanical College, West Raleigh.
Smith, John E., Instructor in Geology, University of North Carolina.
Swarthout, G. E., Professor of Natural Science, Atlantic Christian College, Wilson.
Winters, R. Y., Plant Breeder, North Carolina Agriculture Experiment Station.

The Secretary then read the following letters together with his reply thereto:

Dr. E. W. Gudger,
Secretary, North Carolina Academy of Science,
Greensboro, N. C.

DEAR SIR:—

You are doubtless aware that the Ninth International Zoological Congress is to be held in Monaco, March 25th to 29th 1913. I am to attend the Congress as an official delegate and will sail from New York on March 1st.

If the North Carolina Academy wishes to be represented at this Congress without expense to the Academy, I can act in this capacity should you so desire.

Respectfully,
C. W. STILES.

Dr. C. W. Stiles,
United States Public Health Service,
Washington, D. C.

DEAR SIR:—

You are hereby appointed the official representative of the North Carolina Academy of Science at the Ninth International Zoological Congress to be held at Monaco, March 25-29, 1913. This letter will constitute your credentials to the authorities of the Congress.

Very truly yours,
E. W. GUDGER, *Secretary.*

These were ordered transmitted to the Academy that they might be recorded in the proceedings. There being no further business, the Committee adjourned.

President Brimley called the Academy to order at 3 P. M., 14 members being present, and appointed the following committees:

Auditing—Coker, W. C., Wolfe, J. J., Metcalf, Z. P.

Resolutions—Hutt, W. N., George, W. C., Swarthout, G. E.

Nominations—Edwards, C. W., Wilson, H. V., Binford, Raymond.

The reading and discussion of papers was then begun and continued until adjournment at 5:45 when eight had been read.

At 8:30 P. M. the Academy reassembled in the Physics Lecture Room of the McIver Memorial Building, when, after a cordial address of welcome to the College by President J. I. Foust, President C. S. Brimley of the Academy, delivered his

presidential address on "Zoo-Geography." The Academy then adjourned to the reception hall of the Students' Building, where a reception in their honor was given by the Faculty of the College.

The Academy met in annual business session at 9:20 A. M. Saturday with President Brimley in the chair. The minutes of last meeting were read and approved, and reports of the Secretary and of committees were called for.

The Secretary read an invitation from the Greensboro Country Club, extending to the members of the Academy the courtesies of the Club during their stay in Greensboro. He then reported that on Jan. 1, 1912, the membership of the Academy was 85, that 10 members were lost through resignation, removal from the State, or non-payment of dues, but that 5 new members were elected at the 1912 meeting, making a total for 1912 of 80. By vote of the Academy the Secretary was instructed to confer with the Editor of the MITCHELL JOURNAL to see if it would not be possible to publish in the Proceedings every May a list of the members for the current year.

The Secretary then reported for the Executive Committee its action of yesterday as to membership and place of next meeting. The Nominating Committee offered for officers for 1913-14: President, Franklin Sherman, Jr., State Entomologist; Vice-president, Z. P. Metcalf, Professor of Entomology, Agricultural and Mechanical College; Secretary-Treasurer, E. W. Gudger, Professor of Biology and Geology State Normal College; for additional members of Executive Committee, W. C. Coker, Professor of Botany, University of N. C.; J. J. Wolfe, Professor of Biology and Geology, Trinity College; C. S. Brimley, Naturalist, Raleigh.

The Auditing Committee announced that the Treasurer's report as given below is correct. It was read and ordered printed in the Proceedings:

REPORT OF E. W. GUDGER, TREASURER, 1912-13, APRIL 21, 1913

RECEIPTS

Balance last audit	$193.00
Dues since last audit	84.00
Interest Savings Bank	5.08
Receipts total	$282.08
Expenses total	91.96
Balance total	$190.12

RESOURCES

Savings bank balance	$130.76
Checking bank balance	59.36
Total	$190.12
Dues unpaid (about)	25.00
Stamped Envelopes on hand	1.50
	$216.12
Less outstanding debts	83.00
Estimated Balance	$133.12

EXPENSES

Printing	$ 8.87
Postage	3.14
Typewriting	1.15
Secretary's expenses 1912 meeting	3.80
Proceedings 1912	75.00
Expenses total	$ 91.96

OUTSTANDING DEBTS

Proceedings 1913	$ 75.00
Miscellaneous (about)	8.00
Total	$ 83.00

Note transfer of $13.00 from Savings Bank to Checking Account.

The Committee on Resolutions moved a vote of thanks to the Faculty of the State Normal College for the use of rooms, and for the reception tendered its members; to the press of the city for the excellent manner in which the meeting had been reported, and to the Country Club for its invitation.

The Committee appointed in 1912 to bring in a report with recommendations for laws on ventilation of churches, school

houses, theaters, and other public buildings, was called for. Chairman Edwards reported progress and asked for further time, and on motion was instructed to bring in a report at the 1914 meeting.

At 9:40 A. M., the reading and discussion of papers was resumed and continued until the program was finished when adjournment was had at 1:15 P. M. There were 22 papers on the program, four of which were read by title, one by another member in the absence of its author, and 17 by their authors in the order as shown on the program. The attendance was 28 out of a membership of 76.

The following is a roster of the members of the Academy for 1913-14. The names of those in attendance at the meeting are marked with a star:

Addickes, T. W., Assistant Curator, State Museum, Raleigh.
Allen, W. M., State Feed Chemist, Department Agriculture, Raleigh.
*Balcomb, E. E., Professor of Agriculture, State Normal College, Greensboro.
*Binford, Raymond, Professor of Biology, Guilford College.
Blanchard, Julian, Professor Elect. Eng., Trinity College, Durham.
Booker, Warren H., Assistant Secretary State Board Health, Raleigh.
Boomhour, J. G., Professor Mathematics, Science, Meredith College, Raleigh.
Briggs, R. W., Professor Engineering, Trinity College, Durham.
*Brimley, C. S., Naturalist, Raleigh.
Brimley, H. H., Curator State Museum, Raleigh.
*Bruner, S. C., A and M. College, W. Raleigh.
Cain, William, Professor Mathematics, University of North Carolina, Chapel Hill.
Chrisman, W. G., State Veterinarian, Department Agriculture, Raleigh.
*Clapp, S. C., Orchard and Nursery Inspector, Department Agriculture, Raleigh.
Cobb, Collier, Professor of Geology, University of North Carolina, Chapel Hill.
Coker, R. E., Director U. S. Fisheries Station, Fairport, La.
*Coker, W. C., Prof. of Botany, Univ. of N. C., Chapel Hill.
Collett, R. W., Supt. State Exper. Farms, Swanannoa.
*Cunningham, Bert, Instructor in Sciences, High School, Durham.
*Dixon, A. A., Prof. of Physics, Guilford College.
*Downing, J. S., Prof. of Chemistry, Guilford College.
*Edwards, C. W., Prof. of Physics, Trinity College, Durham.
Ferrell, J. A., Assistant State Board Health, Raleigh.

Fulton, H. R., Professor Botany and Plant Pathology, A. and M. College, W. Raleigh.

*George, W. C., Instructor in Zoology, University of North Carolina, Chapel Hill.

*Gove, Anna M., Resident Physician, State Normal College, Greensboro.

*Gudger, E. W., Professor Biology and Geology, State Normal College, Greensboro.

*Hammel, W. C. A., Professor Physics and Manual Arts, State Normal College, Greensboro.

Harding, W. T., 116 W. Jones St., Raleigh.

*Herty, C. H., Professor of Chemistry, University of North Carolina, Chapel Hill.

Hobbs, A. Wilson, Graduate Student Johns Hopkins University, Baltimore.

Holmes, J. S., State Forester, Geology Survey, Chapel Hill.

*Hutt, W. N., State Horticulturist, Department Agriculture, Raleigh.

Ives, J. D., Assistant in Biology, Wake Forest College, Wake Forest.

*Julian, C. A., Assistant Secretary State Board Health, Thomasville.

Kilgore, B. W., State Chemist, Department Agriculture, Raleigh.

Lanneau, J. F., Professor Applied Math. and Astronomy, Wake Forest College, Wake Forest.

Lay, George W., Rector St. Mary's School, Raleigh.

Lewis, R. H., President North Carolina Association Prevent. Tuberculosis, Raleigh.

MacConnell, J. W., Professor Biology, Davidson College, Davidson.

McIver, Mrs. Chas. D., Spring Garden St., Greensboro.

MacNider, G M., Feed Chemist Department Agriculture, Raleigh.

MacNider, W. de B., Professor Pharmacology, University of North Carolina, Chapel Hill.

Markham, C. B., Assistant Professor Mathematics, Trinity College, Durham.

*Mendenhall, Gertrude W., Professor Mathematics, State Normal College, Greensboro.

*Metcalf, C. L., Entomologist, Department Agriculture, Raleigh.

*Metcalf, Z. P., Professor Entomologist, A. and M. College, W. Raleigh.

Mills, J. E., Consult. and Analyt. Chemist, Columbia, S. C.

Newman, C. L., Professor Agriculture, A. and M. College, W. Raleigh.

Norton, W. C., Asst. in Botany A. and M. College, W. Raleigh.

Patterson, A. H., Professor of Physics, University of North Carolina, Chapel Hill.

Pegram, W. H., Professor of Chemistry, Trinity College, Durham.

Petty, Mary M., Professor of Chemistry, State Normal College, Greensboro.

Poteat, W. L., President and Professor of Biology, Wake Forest College, Wake Forest.

*Pratt, J. H., State Geologist, Chapel Hill.

Radcliffe, Lewis, Director Laboratory U. S. Bureau Fisheries, Beaufort.

Ragsdale, Virginia, Associate Professor of Mathematics, State Normal College, Greensboro.

Rankin, W. S., Secretary State Board Health, Raleigh.

Robinson, Mary, Assistant in Biology State Normal College, Greensboro.

Rosenkrans, D. B., Instructor Botany, A. and M. College, W. Raleigh.

Shaw, S. B., Department Agriculture, Raleigh.

Sherman, Franklin Jr., State Entomologist, Department Agriculture, Raleigh.

Shore, C. A., Director State Laboratory Hygiene, Raleigh.

Smith, J. E., Instructor in Geology, University N. C., Chapel Hill.

Stiles, C. W., Director Marine Hospital, Wilmington.

*Strong, Cora, Associate Professor of Mathematics, State Normal College, Greensboro.

*Swarthout, G. E., Professor Nat. Science, Atlantic Christian College, Wilson.

Tillman, Opal I., Scientific Assistant Department Agriculture, Raleigh.

Venable, F. P., President University of N. C., Chapel Hill.

*Wheeler, A. S., Associate Professor Organic Chemistry, University N. C., Chapel Hill.

Williams, L. F., Associate Professor Chemistry, A. & M. College, W. Raleigh.

*Wilson, H. V., Professor Zoology, University of North Carolina, Chapel Hill.

Wilson, R. N., Professor Chemistry, Trinity College, Durham.

*Winters, R. Y., Plant Breeder, N. C. Agr. Experiment Station, W. Raleigh.

*Withers, W. A., Professor of Chemistry, A. & M. College, W. Raleigh.

*Wolfe, J. J., Professor of Biology and Geology, Trinity College, Durham.

In addition to the presidential address on "Zoo-geography," which is published in the current number of this JOURNAL, the following papers were presented:

WILL CELLS OF THE EMBRYO SEA URCHIN, WHEN REINTRODUCED INTO THE BODY OF THE ADULT, BECOME TISSUE CELLS OF THE LATTER

H. V. WILSON

Plasmodia formed by union of lymph cells were allowed to engulf blastulæ, and were grafted on the wound membranes which close in apertures made in the test of the urchin. The blastulæ after certain changes broke up into their constituent cells. In this way disssociated embryonic cells were brought into the midst of a developing membrane, having a very simple histological character. In the actual experiments a very large proportion of the embryonic cells underwent degeneration. There was some evidence, though by no means convincing, that groups of the smaller cells became part of the developing membrane.

ALTERNATION OF GENERATIONS IN PADINA

JAS. J. WOLFE

While at work on the life history of Padina at the Fisheries Laboratory at Beaufort it seemed worth while to test the theory of alternation of generations in such plants by the cultural methods devised by Hoyt (Bot. Gaz., Jan., 1910). Numerous cultures were made during the summer of 1910 and the next—all having but indifferent success. They were repeated in 1912 with somewhat better results. The cultures of Tetraspores produced a total of 134 male, 154 female, and no tetrasporic plants. Those from fertilized eggs were somewhat less conclusive. Nevertheless, the evidence from cultures strongly supports the view that in Padina there is a real alternation of sporophyte with gametophyte.

GESTATION IN THE NURSE SHARK, *GINGLYMOSTOMA CIRRATUM*

E. W. GUDGER

A brief description was given of the breeding habits and of some points in the embryology of this shark, which was studied at the laboratory of the Carnegie Institution at Tortugas, Florida, in June and July, 1912. A brief account has been published in the Year Book for 1912 of the Carnegie Institution of Washington, Department of Marine Biology, pages 148-150.

HYBRIDIZATION EXPERIMENTS ON FROGS

W. C. GEORGE

Chorophilus n. feriarum was crossed with Acris gryllus. About half of the egg segmented. (In the pure Chorophilus control practically all the eggs segmented). The development was markedly retarded and was abnormal. The conspicuous abnormalities concerned the behavior of the yolk pole. Thus segmentation at this pole was not perfect, and the closure of the blastopore was interferred with in such wise that there developed the well known abnormal type produced in so many ways, characterized by a large blastopore area and the differentiation of the neural plate.

THE TOXICITY OF COTTONSEED MEAL

W. A. WITHERS, J. F. BREWSTER, L. F. WILLIAMS, AND J. W. NOWELL WITH THE COLLABORATION OF R. S. CURTIS AND G. A. ROBERTS

The authors conclude from experiments, some of which have been published:* that the toxicity of cottonseed meal is due to a constituent

and *Journal of Biological Chemitry*, Volume XIV (1913), pp. 53-58.

group of the proteins, probably one containing loosely bound sulphur. They suggest some form of iron as an antidote having found with Belgian hares that citrate of iron and ammonia (0.7 gms. daily) is effective

*Proceedings Society for Promotion Agricultural Science, 1912, pp. 19-21,

in overcoming and in preventing cottonseed meal intoxication. Further experiments are in progress with small animals and with swine. Efforts to isolate the toxic substance will be continued.

FISHING FOR SHARKS IN KEY WEST HARBOR

E. W. GUDGER

In this paper the capture was described of a 7-foot, 10-inch male specimen of *Hypoprion brevirotris* and a 10-foot, 10-inch female specimen of the tiger shark, *Galeocerdo tigrinus*, in Key West Harbor, in July, 1912. These two fishes not being very well known, it is proposed later to publish careful descriptions with exact measurements.

The jaws of the tiger shark, which were exhibited, measured 1 foot 4 inches straight across, and around the curve of the jaws 1 foot 9 inches. Its stomach contained more than a half barrel of miscellaneous material, including a cow's head (dehorned) minus the lower jaws, the vertebral column of a sheep, the scutes of a green turtle, the bones and feathers of two birds, and a lot of tin cans and sea weed. The uteri were dissected, but unfortunately the fish was not in breeding condition.

A SECOND CAPTURE OF THE WHALE SHARK, *RHINEODON TYPUS*, IN FLORIA WATERS

E. W. GUDGER

This paper will be published in full in *Science*.

For the following papers no abstracts have been received:

Some Possible Effects of Solar Rays, (read by title), George W. Lay.
Seasonal Periodicity in the Water Moulds, W. C. Coker.
Vaccination Against Tuberculosis, C. A. Julian.
The Geological History of Western North Carolina, J. H. Pratt.
Action of Ammonia upon Arsenic Iodide, C. H. Herty, & J. T. Dobbins.
A List of the Known Homoptera in North Carolina, Z. P. Metcalf.
The Chestnut Bark Disease, S. C. Bruner.
Serum-Simultaneous Method of Immunizing Hogs Against Cholera. W. C. Chrisman.
Behavior of the Spermatozoa of the Crab, Raymond Binford.
The Granville Tobacco Wilt Problem, (read by S. C. Bruner), H. R. Fulton.
The Swamp Lands of Eastern North Carolina, J. H. Pratt.
The Influence of Environment on Reproductive Processes, W. C. Coker.
Survivals and Adaptions along the South Atlantic Coast: A Study in Anthropegeography, (read by title), Collier Cobb.
A New Interference Apparatus (with a demonstration), C. W. Edwards.
The Closing Up of Lake Basins in Massachusetts, Michigan, and North Carolina (read by title), Collier Cobb.

E. W. GUDGER, *Secretary*.

ZOO-GEOGRAPHY*

A Study of Life Zones

BY C. S. BRIMLEY

The intention of this paper is to discuss briefly, first, the primary life areas of the world, second, the life zones of North America, and thirdly the zoo-geographical divisions of our own state, North Carolina.

The primary life areas of the world appear to me to be five in number, namely:

An Australian Realm, consisting of Australia proper, New Guinea and the adjacent islands as far west as Celebes and Lombok. To these are also added New Zealand and the islands of Oceania.

A Neo-tropical Realm, comprising South America, Central America, the West Indies, and the coasts of Mexico.

An Ethiopian Realm, consisting of Africa south of the Sahara Desert, southern Arabia, and the island of Madagascar.

An Indian or Oriental Realm, including India, Further India, part of southern China, and the neighboring islands of the Malay Archipelago as far east as Borneo and Java.

A Northern Realm, comprising North America, Europe, northern and central Asia, and northern Africa, being equivalent to the combined Nearctic and Palæarctic Realms of Sclater and later writers.

This is practically the first system ever proposed, that of Sclater, 1858, with only one alteration, the combining of his Palaearctic and Neartic Realms into a single Northern Realm. Many systems have been suggested since, these consisting largely of different groupings of Sclater's original six realms, with or without the addition of certain others, constructed either of single islands as in the case of Madagascar, or of groups, as in the case of Oceania. The Arctic regions have also been set off as a distinct realm but this does not seem to be a tenable position as all the Arctic animals belong to families attaining their full development further south. An Antarctic realm has also

*Presidential address before the North Carolina Academy of Science, Greensboro, N. C., April 25, 1913.

been proposed but that would be characterised only by a single family of birds, the penguins, and it seems most advisable in this paper to look upon it as a region of secondary rank, or else to ignore it altogether. It seems to me also better to treat islands having a decidedly distinctive fauna as portions of the realm to which they most nearly approach, rather than to consider them as distinct, as there are all grades of such islands, and to recognize one opens the way to an almost endless list of meager insular realms.

In this paper the distribution of land vertebrates only will as a rule be taken into account, and greater weight will be given to the occurrence of mammals, reptiles, and amphibians, than to that of birds, as the latter, owing to their powers of flight and migratory habits are less reliable indications of the zoological character of a region than the former. Both fishes and birds will however be used whenever it seems advisable.

As the Northern Realm is distinguished from the group of four southern realms, more by the lack of the groups peculiar to them than by the presence of distinctive forms of its own, I will leave the discussion of its animals to the last, and take up the southern realms first, in the order in which they have been previously named. A further reason for this lies in the fact that after discussing the realms in general, I shall treat the life zones of North America, a portion of the Northern Realm, and this arrangement allows me to approach this second part of my subject in a natural and convenient way.

The Australian Realm comprises not only Australia, New Guinea, and the neighboring islands as far west as Celebes and Lombok, but also New Zealand and the islands of Oceania, which two last may be looked upon as outlying provinces and taken up later.

It is one of the most sharply characterised of the realms, its main features being the presence here, and here only, of the egg-laying mammalia, and the great development of marsupial mammals and elapid serpents to the exclusion of other forms of these groups, these being represented in Australia only by a few rodents and bats on the one hand and a few harmless snakes on

the other. Its marsupials and other distinctive forms become mingled with Asiatic species in the islands westward of New Guinea, but both marsupials and ostrich-like birds (which here attain their greatest development) extend up to and including the islands of Lombok and Celebes, but not across the straits to Borneo or Java. Side-necked turtles, and lung fishes are also represented here, as well as in the Neo-tropical and Ethiopian realms, but no cecilian amphibians.

New Zealand lacks most of the Australian forms, but is remarkable for the possession of the only living representative of the reptilian order Rhynchocephalia, while the islands of Oceania possess a fauna which, as we might naturally expect, is so largely composed of birds that they have sometimes been erected into a zoo-geographical realm under the name of Ornithogæa or the bird world.

The Neo-tropical Realm includes South and Central America, the coast lands of Mexico and also the West Indian islands. The presence of high mountains whose peaks reach above the snowline and the southward extension of the continent into cooler latitudes combined with tropical conditions over most of the realm make a homogeneous fauna impossible, still the whole realm shows marked distinctions from any other.

New-world monkeys, mormosets, sloths, ant-eaters, armadillos, and true opossums, the only family of pouched mammals found outside Australia, are all peculiar types characteristic of this realm only, while its rodent family Caviidæ contains the largest of all the order, one species, the capybara, reaching a weight of 100 pounds. Leaf-nosed or vampire bats are found exclusively here while the fruit bats of the other three southern realms are absent, as are also terrestrial insectivores. Hollow-horned ruminants are wholly absent, the hoofed mammals being represented by deer, tapirs, llamas, and peccaries.

Among birds members of the ostrich family occur, as well as many peculiar forms, such as the tinamous, toucans, and humming birds, the last being a highly characteristic and widespread family.

Crotalid, elapid, and boid snakes are represented in its fauna,

as well as side-necked turtles, lungfishes, and cecilian amphibians. Salamanders are practically absent.

The islands of the Greater Antilles deserve mention as lacking the terrestrial mammals of the neighboring mainlands, its only prominent forms being the rodent genus, Capromys, and the insectivorous genus Solenodon.

The Ethiopian Realm includes not only Africa south of the Sahara Desert, but also the island of Madagascar and southern Arabia. As the two latter, however, can only be considered as outlying provinces, and do not exhibit the more prominent features of the main portion of the realm they will be treated of separately, and are not included in the statements that immediately follow.

Its characteristic animals are the hippopotamus, giraffe, hyrax or coney, zebra, rhinoceros, elephant, old world monkeys, great apes (gorilla and chimpanzee), lemurs, scaly ant-eaters, aard vark, several families of insectivorous mammals (golden moles, jumping shrews, and some others), hyænas, ostrich-like birds, elapid, and boid snakes, side-necked turtles, cecilians or worm-like amphibians, and lung fishes. The greater number of these forms are represented in other realms as well, but the first four mentioned, as well as the aard vark, golden moles and jumping shrews do not occur elsewhere. No bears, deer, nor salamanders of any kind occur. Its main feature, however, is the great abundance of hoofed mammals, particularly those of the hollow-horned or antelope family which here attains by far its highest point, both in number of species and number of individuals.

Of its outlying portions the presence of conies and ostriches in southern Arabia would seem to indicate Ethiopian affinities, though most of the continental African forms are lacking.

The island of Madagascar on the other hand has a very peculiar fauna of its own, more than one-half of its mammals belonging to the lemur family, while the remainder are largely insectivora not found elsewhere, the large hoofed mammals, and the carnivora of the mainland being lacking.

The Indian or *Oriental Realm* comprises southeastern Asia,

south of the Himalaya Mountains, as well as the islands of the Malay Archipelago as far east as Borneo and Java.

It has been combined by some with the Palæarctic and Nearctic realms to form a single Arctogæan Realm, but it appears to me to have too many southern forms to justify such an arrangement, while others have combined it with the Ethiopian to form an Indo-African realm but here the lack of too many of the Ethiopian forms seems to be a sufficient bar to any such proceeding.

It possesses few peculiar groups of animals, the families Tupaiidæ (tree shrews), Galeopithecidæ (flying lemurs), and Tarsiidæ being the most noteworthy among the mammals, but the majority of its characteristic groups are shared with other realms, thus its elephants, hyænas, rhinoceros, scaly ant-eaters, lemurs, old world monkeys, and great apes are represented also in Africa, though by other species. Its boid snakes, and cecilian amphibians are similarly found also in both the Ethiopian and Neo-tropical realms. Its bear and deer and most of its insectivorous mammals are otherwise mainly northern groups, while it possesses in common with the Neo-tropical realm representatives of the tapir family. Lung fishes, side-necked turtles, and ostrich-like birds are absent, while elapid serpents are present, as they are also in all the other southern realms, being one of the very few groups found in all four tropical realms, and not elsewhere, the parrots being the only other vertebrate group which I can remember as having a similar range.

The *Northern Realm* comprises all the earth's land surface lying north of the boundaries of the four southern realms.

It is characterised more by what it lacks than by what it possesses, few groups of animals being confined exclusively within its borders.

No elephants, tapirs, rhinoceros, hippopatamus, giraffes, conies, no lemurs, monkeys of any kind, nor great apes, no edentates or marsupials, no egg-laying mammals, hyænas or cavies, no ostrich-like birds, no alligators, no boid nor elapid serpents, no side-necked turtles, no cecilian amphibians nor lung fishes occur, except that in the case of some of these groups a single species or two intrudes more or less into its limits.

Bears, deer, and insectivorous mammalia occur throughout practically its entire extent, tailed amphibians (salamanders) are found throughout its temperate regions and here alone.

It appears to me to fall into three natural divisions:—

1. *An Arctic Region,* comprising the circumpolar regions as far south as the northern limit of the growth of trees.

2. *An Eurasian Region,* (equivalent to Sclater's Palæarctic Realm, with its Arctic portion deducted), comprising Europe, north Africa, and Asia, north of the Indian Realm.

3. *A North American Region* (equivalent to Sclater's Nearctic Realm less Arctic North America), comprising all North America south of the Arctic regions and north of the Neo-tropical realm.

The *Arctic Region* is characterized by the scantiness of its fauna which is circumpolar for the most part, its most prominent mammalian components being the polar bear, Arctic fox, Arctic wolf, Arctic hares, reindeer, and musk ox, the last being American only.

The *Eurasian Region* possesses the following forms not found in North America, though mainly in other regions, in Insectivora, the hedgehogs, in Ungulata, the true oxen and buffaloes, the pigs, wild goats, and several species of antelopes. In reptiles it possesses true viperine serpents, and in birds, true flycatchers (Muscicapidæ), bustards (Otidæ), old-world warblers (Sylviidæ), true larks (Alaudidæ) and wagtails (Motacillidæ), the last three families being also very sparingly represented in America.

The *North American Region* lacks the above mentioned Eurasian forms and possesses the following peculiar ones: prong-horn antelope, skunks, o'possum, raccoon, star-nosed mole, mole shrews, and perhaps a few other mammals. Hoofed animals are comparatively poorly represented, there being, except the various deer, only the prong-horn, rocky mountain sheep, rocky mountain goat, and American bison, the last now nearly extinct. Among birds the wood warblers, tanagers, mocking thrushes, new world vultures, tyrant fly catchers and humming-birds distinguish it from the Eurasian region, but all of them

occur more or less abundantly in the Neo-tropical realm to the southward. In reptiles it possesses pit vipers but no true vipers, and among the former the rattlesnakes are exclusively American and predominantly North American. In the Amphibia its characteristic species belong to the tailed forms among which the large family Plethodontidæ is exclusively North American while the smaller families of Sirenidæ, and Amphiumidæ containing the large eel-shaped salamanders are not found elsewhere.

THE LIFE ZONES OF NORTH AMERICA

These are more or less parallel belts running across the continent from east to west, and are limited mainly by the mean temperature of the region, which in its turn is determined by the two factors of latitude and elevation. Of course other factors play a large part in determining the life of these regions, the most important being the comparative humidity, in fact this last element splits three of our southerly life zones into two distinct portions, an eastern or humid division and a western or arid division.

These life zones are seven in number, the three northern being cold or boreal in character, while the four southern are warm or austral. Of course each zone grades into both the one above and the one below, so that there is never a hard and fast dividing line between any two contiguous ones, still in spite of this each zone is fairly well characterized by the forms of life or by the combination of forms occurring in it.

The transcontinental zones are,—

1. *An Arctic Zone,* forming the American portion of the Arctic region, including all the country north of the northern limit of trees.

2. *A Hudsonian Zone,* including the northern half of the boreal forest region.

3. *A Canadian Zone,* including the southern half of the boreal forests. These three zones cover by far the greater part of Canada and enter the United States, mainly along its chief mountain ranges at high elevations.

4. *An Alleghanian Zone,* which includes, roughly speaking, the northern United States.

5. *An Upper Austral Zone*, covering the middle portion of the United States, and divided into an eastern or humid portion (the Carolinian district), and a western or arid portion (Upper Sonoran).

6. *A Lower Austral Zone,* comprising the southern United States and the central plateau of Mexico, likewise divided into an eastern (Louisianian) or humid region, and a western (Lower Sonoran), or arid region.

7. *A Tropical Zone,* comprising all south of the Lower Austral.

The main characteristics of these zones are as follows:

1. *The Arctic Zone* is distinguished by an entire absence of trees, the vegetation consisting of stunted shrubs, low flowering plants, and lichens. Among the vertebrates, reptiles and amphibians are wholly lacking, while mammals are represented by the musk-ox, barren ground caribou, arctic hare, several species of lemmings, arctic fox, and near salt water and on the islands of the Arctic sea, by the polar bear. On the summits of the Rocky Mountains and of the Sierras where isolated patches of this zone occur at high altitudes these are all absent, but pikas, mountain sheep, and marmots occur at least in summer. Among the breeding birds of the Arctic zone are the snow geese and gyrfalcons and quite a number of shore birds. The mean temperature of the six warmest months at the lower edge of this zone is said to be about 50 F.

2. *The Hudsonian Zone* is a belt of more or less stunted timber lying due south of the preceding. Like it, it lacks all reptiles and amphibians, and also all the characteristic Arctic mammals as well, this being due not alone to the higher temperature but largely also to the forested character of the country, which prevents it being congenial to the animals which inhabit the treeless country further north. For the same reason the forest loving forms of the north, such as the wolverine, fisher, marten, Canada lynx, woodland caribou, moose, and black bear

do not range further northward. There seem to be no mammals peculiar to it and it is chiefly distinguished from the Canadian zone by what it lacks. Most of its characteristic mammals occur also on the isolated patches of it which lie on the sides of the western mountains below timber line. The mean temperature of the lower edge of this zone during the six warmest months in the year is said to be about 57 F. From its forested area, largely consisting of spruces, it is often known as the Spruce Zone.

3. *The Canadian Zone* includes the forested region consisting largely of balsams and firs which lies south of the Hudsonian, and does not differ from it greatly in character. It, however, is the most northern zone in which cultivated crops, such as potatoes, barley, etc., can be raised, and also is the most northerly zone in which any mammals of presumably southern origin occur. Thus chipmunks, white-footed mice and wood rats do not extend their range northward beyond it. Practically all the mammals mentioned above as belonging to the Hudsonian zone belong here also and these do not range southward below it (except the black bear). It possesses a few amphibians, such as frogs of the genus Rana, and salamanders of the genera Desmognathus and Amblystoma as well as a number of peculiar mountain forms. The temperature of the six warmest months of the year is estimated to be about 60 F.

4. *The Alleghanian Zone* includes the white pine forests of the north and the contiguous regions, and is the most northerly region having any reptilian fauna. The blue-tailed and fence lizards, the water, garter, chicken, ground, and green snakes as well as the copperhead, banded rattlesnake and massasauga do not extend north of it, nor in mammals do the cottontail rabbit, common mole, and raccoon, while the starnosed and Brewer's moles are confined to this zone and the Canadian. Salamanders attain their highest degree of development in this zone and the succeeding one.

5. *The Upper Austral Zone* is a tract of country in which the trees are mainly deciduous, thus forming a contrast to the coniferous forests of the north and south, between which it lies. Among mammals the gray fox, and opossum do not occur above

its northern boundary while the woodchuck, red fox, weasel, and chipmunk do not extend below its southern border. Its reptiles are much more numerous than those of the Alleghanian, but far less so than those of the Lower Austral. It divides naturally into an eastern or humid division and a western or arid one, the former being characterized by an abundance of turtles, and a scarcity of lizards while the latter has an abundance of lizards and very few turtles.

6. *The Lower Austral Zone* comprises roughly speaking the southern third of the United States and a large part of Mexico. It is characterized by a great abundance of reptiles and a comparative lack of salamanders though certain highly specialized forms of the latter belong exclusively here. Its distinctive mammals are the marsh and water rabbits, the cotton rats, and ricefield rats, and a few others. Its peculiar reptiles are many and will be mainly listed in the part on the life zones of North Carolina. The alligator, diamond rattlesnake, and coral snake are among its more striking representatives in the reptiles.

THE LIFE ZONES OF NORTH CAROLINA

Four of the life zones of North America enter the confines of our states, these are:

1. *The Canadian Zone.*
2. *The Alleghanian or Transition Zone.*
3. *The Upper Austral* or *Carolinian Zone.*
4. *The Lower Austral* or *Louisianian Zone.*

1. The Canadian Zone occupies the summits of the higher mountains from about 4,500 feet up, though some of its characteristic forms occur lower down still.

Its mammals are

Cloudland Deer Mouse, above 5,000 feet.
Carolina Red-backed Mouse, above 4,000 feet.

And there seem to be no other species of general distribution in the mountains which are confined to this zone, but its breeding birds are more distinctive, these being:

Pine Siskin, above 5,000 feet.
American Crossbill, above 5,000 feet.
Winter Wren, above 4,000 feet.
Brown Creeper, above 4,000 feet.
Redbreasted Nuthatch, above 5,000 feet.
Chickadee, above 5,000 feet.
Gold crowned Kinglet, above 5,000 feet.
Olive-sided Flycatcher, above 4,000 feet.
Yellow-bellied Sapsucker, above 4,000 feet.

The zone has not peculiar reptiles, those entering it, if any, being species occurring in the Alleghanian zone below. Its distinctive amphibians are also few, the most characteristic being *Plethodon metcalfi;* which however, ranges as far down as 3,500 feet, *Plethodon shermani* and *Gyrinophilus porphyriticus* also seem to belong to this zone, though the first seems to be a local form of very limited range, and of the latter we have only two records, one of them quite unsatisfactory.

The specific points which we are able to include in this zone from a more or less complete knowledge of their fauna are, the Black Mountains in Yancey and Buncombe Counties; Roan Mountain, in Mitchell County; Grandfather Mountain in Watauga County, Pisgah Ridge, and the Balsam Mountains in Haywood County, the high mountains near Highlands, in Macon County, Tuskwitty Mountain and Wayah Bald, also in Macon County. Besides these the mountains along the state line north of Cherokee County, as far as Roan Mountain, must possess a Canadian fauna on their summits owing to their elevation and the same is also true of all our mountains not named, which reach 5,000 feet elevation and over.

2. *The Alleghanian Zone* occupies the greater part of the mountain region, its limits extending from about 2,500 feet to 4,500 feet, though many of its characteristic species extend upwards into the Canadian, or downwards into the Upper Austral as well.

The following mammals do not appear to range below this zone: red squirrel, woodchuck, starnosed and Brewer's moles, mole-shrew, masked and smoky shrews, while the opossum,

woodchuck, gray squirrel, common deer mouse and common mole do not occur above it.

With birds the case is quite similar. The scarlet tanager, rosebreasted grosbeak, vesper sparrow, Carolina junco, song sparrow, Baltimore oriole, Cairns, Canadian, blackthroated green, blackburnian, golden-winged, and chestnut-sided warblers, Bewick's wren, warbling vireo, Wilson's thrush, least flycatcher and ruffed grouse not ranging below it, while the Carolina wren, crow, tufted tit, bluegray gnatcatcher, brown thrasher, yellowthroated vireo, Kentucky warbler, summer tanager, field sparrow, acadian flycatcher, and redbellied woodpecker do not pass beyond its upper limits. Not all of either class however ranges throughout its whole extent, a noteworthy exception being the Carolina junco, which is essentially a bird of the Canadian zone, but ranges in diminished numbers down to 3,000 feet, or about half way through the Alleghanian zone, and there are many similar instances.

In reptiles the milk snake alone appears to be confined to this zone, but the ring-necked snake, banded rattlesnake, garter snake, northern water snake, black chicken snake, black snake, fence lizard, blue-tailed lizard, and perhaps others also occur here as well as in the warmer zones below, and some of them may enter the Canadian zone above.

Its characteristic amphibians are wholly salamanders, the most widely distributed being the mountain triton (*Desmognathus 4-maculatus*) which occur in small streams throughout its whole extent. Another species is the round-tailed triton (*Desmognathus achrophea*) which though ranging in diminished numbers down to 3,000 ft. reaches its greatest abundance in the Canadian zone above. Daniel's triton (*Spelerpes danielsi*) and Schenck's triton (*Spelerpes schencki*), the former a rare, the latter a common, species seem to be confined to this zone. The viscid salamander extends upwards through this zone to about 3,500 ft. at which elevation it is replaced by Metcalf's salamander.

3. *The Upper Austral or Carolinian Zone.* This includes the central portion of the state, West and North of a line drawn

from a little West of Weldon, and thence through Raleigh to Charlotte. Its general western boundaries are the western limits of Surry, Wilkes, Caldwell, and Burke counties, some of all of which lie outside its limits. McDowell lies half in and half out of the zone, while Henderson is almost wholly outside and Polk almost wholly inside. Besides this it includes the mountain valleys below about 2,500 ft. the principal of them being those of the Hiwasee in Cherokee County, of the Little Tennessee in Graham, Swain, and Macon Counties, of Pigeon River in Haywood, and last but not least of the French Broad in Madison, Buncombe, Henderson, and Transylvania Counties.

Less collecting, especially if we exclude birds, has been done in our state in this zone than in any other, but fortunately what has been done has been largely near its edges and shows tolerably well how it differs from the zones above and below. Its faunal characteristics are furthermore much influenced by the comparative low latitude in which our portion of it lies so that we have an intrusion of certain Lower Austral forms and an exclusion of others which further north are characteristic of this zone.

We can define this zone but little by its mammalian fauna, still the golden mouse ranges throughout it but not above it, while the chipmunk, weasel, meadow mouse, jumping mouse, common deer mouse and muskrat, are also widely distributed forms whose range is largely defined by its southern border.

In birds the mocking bird, prairie warbler, pine warbler, yellowthroated warbler, blue grosbeak, brownheaded nut-hatch and Bachman's sparrow all occur more or less commonly up to its upper edge, the last four being normally Lower Austral species, while on the other hand the whippoorwill, robin, goldfinch, and yellow warbler do not range to any extent below its southern limits.

In reptiles it possesses one peculiar species, the brown king snake, a serpent of very limited distribution, but several do not range above it, these being the southern green snake, common king snake, Valeria's snake, ground lizard, and sand lizard. The black chicken snake, queen snake, and painted turtle do

not seem to extend their range much if any beyond its southern limits, while the northern water snake, although normally not occurring below this zone, ranges in this state throughout the Lower Austral also.

Among amphibians, the spotted salamander, marbled salamander and Holbrook's triton occur throughout it but not above its upper boundary, while the range of the pickerel frog does not extend below its southern limits.

From the Lower Austral it is mainly distinguished by the absence of the long list of reptiles and amphibians occurring in that zone and not above it. Some of these however enter the Upper Austral along its southern border, thus we have the green lizard recorded from Tryon in Polk County, and Albemarle in Stanley County, while the glass snake has been taken at Statesville. Other records of Lower Austral forms possibly still more surprising are of the lubber grasshopper near Concord in Cabarrus County, and a true scorpion at Tryon in Polk County.

4. *Lower Austral Zone,* includes the remainder of the state, namely all lying south and east of a line drawn from near Weldon to Raleigh, and thence to Charlotte, and it may be as well to give some idea of how we came to locate the line. In the first place, Raleigh, where the fauna is known in its entirety for all practical purposes, has a thoroughly mixed fauna and can hardly be placed in either zone, thus both the whippoorwill and chuckwillswidow, one typically Upper, and the other typically Lower Austral, both occur and breed. Other Upper Austral breeding birds are the robin, goldfinch, mountain vireo, and yellow warbler, while the prothonotary warbler, a Lower Austral form, barely reaches Raleigh. In reptiles we have here the following Upper Austral species: brown king snake, queen snake, black chicken snake, northern water snake, and painted terrapin, and these Lower Austral forms: glass snake, corn snake, southern water snake, cottonmouth, red-bellied water snake, crowned tantilla, red king snake, scarlet snake, and two species of terrapin (*Pseudemys concinna* and *P. scripta*). In amphibians the balance also turns to the Lower

Austral as the ditch eel (*Amphiuma means*), dwarf salamander and narrow-mouthed toad are all common, while the Upper Austral pickerel frog is only tolerably so. In mammals its Lower Austral forms are the cotton rat and Carolina mole-shrew, both of which may very likely range considerably into the Upper Austral in this state, while of Upper Austral forms, the chipmunk is common a few miles west of Raleigh, but not at Raleigh, while the meadow mouse, common deer mouse, muskrat, jumping mouse and weasel are all common except the last two.

Hence we see Raleigh rather leans to the Upper Austral on birds and mammals, and to the Lower on reptiles and amphibians, and is plainly an intermediate point so we draw the line right through it, then knowing that the line must necessarily slant northward towards the coast, we draw it straight to Weldon, having records of the occurrence of typical Lower Austral forms just east of that place. To the south we find that Southern Pines with records of the scarlet snake, coachwhip, corn snake, narrowmouthed toad, crowned tantilla, and red-cockaded woodpecker ought to be placed well within the line, which is confirmed by the occurrence of the green lizard at Carthage a little to the north, and of the coral snake at Montrose to the south. So we draw the line above Southern Pines, and then finding records of such species as the green lizard in Stanly County, and the lubber grasshopper in Cabarrus County which latter record is offset by the presence of the chipmunk, at the same place, indicating a mixed fauna, we continue it through these counties to Charlotte and thence to the state line in the same general direction.

The animals which we have considered as characterising the Lower Austral Zone in this state are as follows:

1. Mammals
   - Marsh Rabbit (Lepus palustris).
   - Southern Fox Squirrel.
   - Cotton Rat (Sigmodon hispidus).
   - Ricefield Rat (Oryzomys palustris).
   - Cotton Mouse (Peromyscus gossypinus).

Carolina Mole Shrew (Blarina carolinensis).
Southern Shrew (Sorex longirostris).
Big-eared Bat (Corinorhinus macrotis).

2. Birds (occurrence in the breeding season only taken into consideration).*

a Land Species.
Chuck-wills-widow.
Red-cockaded Woodpecker.
Prothonotary Warbler.
Swainsons Warbler.
Nonpareil or Painted Bunting.

b Shore and Water Birds.
American Egret.
Snowy Egret.
Florida Cormorant.
Louisiana Heron.
Little Blue Heron.
Boat-tailed Grackle.

3. Reptiles.
Alligator (Alligator mississippiensis).
Florida Terrapin (Pseudemys floridana).
Mobile Terrapin (Pseudemys mobilensis).
Yellow-bellied Terrapin (Pseudemys scripta).
Smooth Terrapin (Pseudemys concinna).
Diamond Rattlesnake (Crotalus adamanteus).
Ground Rattlesnake (Sistrurus miliarius).
Cottonmouth Mocassin (Ancistrodon piscivorus).
Coral Adder (Elaps fulvius).
Crowned Tantilla (Tantilla coronata).
Rainbow Snake (Abastor erythrogrammus).
Horn Snake (Farancia abacura).
Southern Hog-nosed Snake (Heterodon simus).
Striped Chicken Snake (Coluber quadrivittatus).

*The following birds usuallly considered as typically Lower Austral forms range in this state throughout the Upper Austral also and help to define it as opposed to the next more northern zone, the Alleghanian: blue grosbeak, Bachman's sparrow, brown-headed nuthatch and yellow-throated warbler.

Corn Snake (Coluber guttatus).
Red King Snake (Ophibolus doliatus cocoineus).
Scarlet Snake (Cemophora coccinea).
Pied Water Snake (Natrix taxispilota).
Southern Water Snake (Natrix fasciata fasciata).
Red-bellied Water Snake (Natrix fasciata erythrogastra).
Coachwhip (Bascanium flagellum).
Brown-headed Snake (Rhadinaea flavilata).
Glass Snake (Ophisaurus ventralis).
Green Lizard (Anolis carolinensis).

4. Amphibians.
Mud Eel (Siren lacertina).
Southern Water Dog (Necturus punctatus).
Ditch Eel (Amphiuma means).
Dwarf Salamander (Manculus quadridigitatus).
Margined Salamander (Stereochilus marginatus).
Narrow-mouthed Toad (Engystoma carolinense).
Dwarf Toad (Bufo quercicus).
Pine-woods Tree Frog (Hyla femoralis).
Squirrel Tree Frog (Hyla squirrella).
Carolina Tree Frog (Hyla cinerea).

5. Fish.
A Top Minnow (Heterandria formoso).
Ditch Fish (Chologaster cornutus).
Everglade Perch (Elassoma evergladei).
Swamp Darter (Copelandellus quiescens).

Not all of these species range throughout the whole zone, a great many of them not appearing to occur further north than Neuse River, while others again seem to be confined to the coastal region though ranging throughout the whole extent of that, in fact, there are all sorts of irregularities in the distribution of these species. Those confined to the coastal region are the following: rainbow snake, horn snake, striped chicken snake, diamond rattlesnake, pied water snake, mud eel, all the three tree frogs mentioned, all four fishes, probably the cotton mouse, and the water and shore birds mentioned. Those ap-

parently extending their ranges north of Neuse River are coach-whip snake, ground and diamond rattlesnakes, nonpareil, Florida cormorant, coral snake, and some others, but our data with regard to many of the species is so meager that we cannot draw any definite conclusions from it.

In part of the zone lying north of Neuse River there appears to be a much greater admixture of Upper Austral forms than further south; in fact, south of that line we meet with only scattering examples of species belonging to the more northern zone. Thus the localities lying on or above Neuse River (excluding Raleigh) give a total of 49 Lower Austral records, to 18 Upper Austral, while those localities southward give only 5 Upper Austral records to a total of 95 Lower Austral, thus showing a much greater intermingling as we go northward which is just what we ought to expect, as no life area is ever homogenous, but gradually blends on the borders with the adjoining ones or areas, consequently the boundaries we draw between any two contiguous zones are largely arbitrary, and if we drew maps to record things exactly as they are we would cause the colors of adjoining zones to gradually blend the one into the other just as their fauna actually blends.

RALEIGH, N. C.

METHODS FOR THE PREPARATION OF NEUTRAL SOLUTIONS OF AMMONIUM CITRATE[1]

BY JAMES M. BELL AND CHARLES F. COWELL

The method at present approved by the Association of Official Agricultural Chemists[2] for the preparation of neutral solutions of ammonium citrate requires the use of an alcoholic solution of corallin as indicator. It is common knowledge that this method is not accurate. The method proposed by Hand,[3] using purified litmus solution, has been thoroughly tried by Patten and Robinson[4] and like the corallin method has proven much less satisfactory than the conductivity method proposed by Hall and Bell.[5] By this conductivity method a series of solutions is prepared containing constant quantities of citric acid and variable quantities of ammonia in a constant volume. It was found that the solution just neutral has the highest electrical conductivity, the plot for conductivity and quantity of ammonia consisting of two curves intersecting at the neutral point. Up to that point the solutions consist of mixtures of ammonium citrate and free citric acid, and beyond the break the solutions consist of mixtures of ammonium citrate and free ammonia.

The conductivity method requires some temperature control, for the temperature coefficient of conductivity is large enough to cause serious errors in the final result unless the maximum variations in temperature are but very slight. Two further methods are here presented for the determination of the neutral point, neither of which requires careful temperature regulation. In one method there is an indirect determination of the excess of ammonia just past the neutral point by the use of chloroform as solvent. This method is called the "extraction method." The second method like the conductivity method is a physical method depending on the great heat evolution when ammonia and citric acid solutions are mixed. This has been called the "temperature method."

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[1]Reprinted from The Journal of the American Chemical Society, Vol. XXXV. No. 1. January, 1913.
[2]Bureau of Chemistry, *Bull.* 107 (revised), 1.
[3]Bureau of Chemistry, *Bull.* 132, 11.
[4]*J. Ind. Eng. Chem.*, 4, 443 (1912).
[5]*J. Am. Chem. Soc.*, 33, 711. (1911.)

1. *Extraction Method.*—Ammonia is soluble to a slight extent in chloroform; citric acid and ammonium citrate are insoluble in chloroform. This fact affords an accurate method of estimating the excess of ammonia in an aqueous solution of these substances. The distribution ratio of ammonia between chloroform and water has been shown by Bell and Feild[6] to be about 1:25 at ordinary temperatures; that is, between equal volumes of water and chloroform, free ammonia will distribute itself about $^1/_{26}$ in the chloroform layer and $^{25}/_{26}$ in the water layer.

A citric acid solution containing 370 grams per liter was prepared. To 100 cc. lots of this solution varying amounts of strong ammonia were added and the resulting solutions diluted to 200cc. This addition was made through a narrow tube leading into the acid so as to avoid losses of ammonia by volatilization. Of this solution 100cc. were shaken out with 125cc. of chloroform and 50cc. of this chloroform layer to which about 50cc. of water were added was titrated against 0.1 N hydrochloric acid solution using methyl red as indicator. During this titration all the ammonia passed from the chloroform layer to the water layer as it was neutralized by the acid. In these determinations only a part of the total excess of ammonia is estimated, but knowing what fraction is taken, the total excess of ammonia may be estimated. For each gram of free ammonia left in 100 cc. of the water layer after shaking out, there is 0.04 gram in 100 cc. of the chloroform layer or 0.05 gram in 125 cc. of the chloroform layer. Hence, of the total excess of ammonia in the sample $^1/_{21}$ is in the 125 cc. of chloroform. In 50 cc. there are $^2/_{105}$ of the portion shaken out and as only half of the total is shaken out there is $^1/_{105}$ of the total excess of ammonia actually titrated.

TABLE I

Ammonia solution used. Cc.	0.1 N HCl: required to neutralize 50 cc. chloroform extract. Cc.
40.5	1.50
40.2	0.97
40.0	0.47
39.8	0.22
39.5	0.00

[6] *J. Am. Chem. Soc.*, 33, 940 (1911).

The proportion in which the citric acid and ammonia solutions must be mixed to give a solution exactly neutral may be found by a graphic method. In Fig. 1 the number of cc. of ammonia added is abscissa and the number of cc. of acid required to neutralize the excess of ammonia in 50 cc. of the chloroform layer is ordinate. By extrapolating it is seen that 39.7 cc. of ammonia solution would just neutralize the amount of the citric acid solution employed. No trace of free ammonia was found in any of the solutions to which 39.5 cc. or less of the ammonia solution had been added.

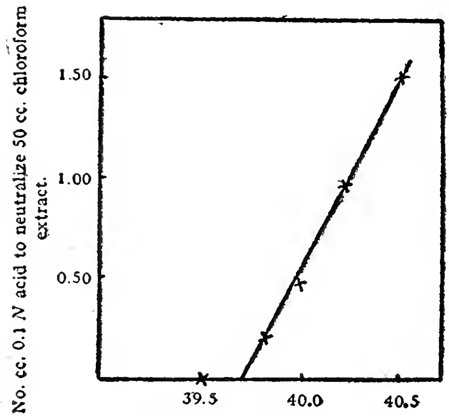

Fig. 1.

When as much as 40.0 cc. had been added, the free ammonia could be detected by odor and these solutions showed increasing amounts of ammonia in the titrations. The solution containing 39.8 cc. of ammonia contained very little free ammonia, for 50 cc. of the chloroform extract required only 0.22 cc. of the acid. It will be seen that this method will indicate the proportions in which the solutions of ammonia and citric acid must be mixed with at least the accuracy which is possible in the ordinary comparison of an acid and base by buret readings.

II. Temperature Method.—The second method here presented for the preparation of a neutral solution of ammonium citrate, like the conductivity method, is a physical method. It was suggested by the fact that, during the addition of the first 35 cc. of ammonia to the citric acid in the former method, so much heat was developed that the solution had to be cooled at least twice during the mixing. After the neutral point is reached, there is no appreciable heat effect due to further additions of ammonia.

The experiments were carried out in a Dewar flask of about 200 cc. capacity, provided with a platinum stirrer and a thermometer graduated to tenths of degrees. The citric acid and ammonia solutions were the same as those used in the former method. Again, 100 cc. of citric acid solution was partially neutralized with 36 cc. of ammonia solution in an ordinary beaker. The cooled solution was then poured into the Dewar flask. The beaker was washed several times with water and the washings poured into the Dewar flask, so that the final volume of solution was about 150 cc. Just as in the previous

TABLE II

Total ammonia added. Cc.	Temperature.
36.0	21.50°
36.5	21.88
37.0	22.25
37.5	22.62
38.0	23.04
38.5	23.40
39.0	23.70
39.5	24.12
40.0	24.28
40.5	24.30
41.0	24.30
42.0	24.32
45.0	24.32

method, the ammonia solution was added from a buret provided with a small delivery tube, which extended to the bottom of the flask. Ammonia was now added in portions of 0.5 cc. and the mixture stirred for about ½ minute. After 1½ minutes no further rise of temperature was noticed. After each addition of 0.5 cc. of ammonia there was a constant rise of temperature of about 0.40° until the buret reading was 39.50 cc. of ammonia. For the next 0.5 cc. of ammonia the rise of temperature was only 0.16°. Beyond 40 cc. practically no change in temperature occurred. The neutral point is therefore between 39.5 cc. and 40 cc. of ammonia. The exact neutral point is found by plotting the curve, using the number of cc. of ammonia as abscissa and the

rise of temperature as ordinate. This point is found to be 39.7 cc., the same reading as was found by the extraction method.

The "temperature method" was further confirmed by its use with solutions of sulphuric acid and ammonia, both about twice normal. The rise of temperature, taken with the same thermo-

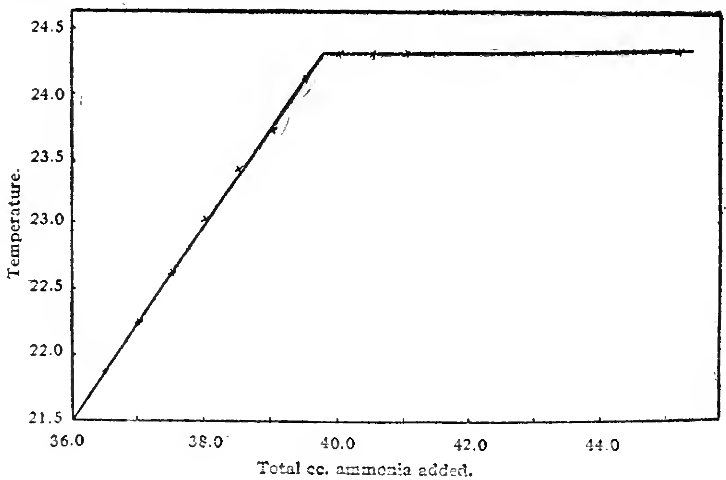

Fig. 2.

meter, as before, was constant until the neutral point was reached. The results obtained are given in Table III and the neutral point agrees exactly with that found by the direct titration of the ammonia against the acid.

TABLE III

Cc. Ammonia added to 40 cc. acid.	Temperature.
38.5	27.62°
39.0	27.70
39.5	27.79
40.0	27.88
40.5	27.96
40.1	28.05
41.5	28.05
42.0	28.01
42.5	27.98
43.0	27.95

Both methods here presented are for the determination of the proportion in which ammonia and citric acid must be mixed to arrive at a neutral solution. These proportions vary of course with the strength of the separate solutions. From the proportion found large quantities of neutral ammonia citrate may be prepared, after which the solution may be diluted to the required density.

SUMMARY

In this paper two methods are proposed for the determination of the end point in the titration of a weak acid by a weak base, where the ordinary indicators fail. In the first method an index of the excess of ammonia is obtained by shaking out with chloroform and by titrating the chloroform with a dilute acid. In the second method the rise in temperature due to the heat of neutralization is observed as the titration proceeds, the end point being at the break in the heating curve. Both these methods are simpler than the method formerly proposed where the conductivities of solutions must be determined at constant temperature.

CHAPEL HILL, N. C.

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GEOLOGICAL HISTORY OF WESTERN NORTH CAROLINA

BY JOSEPH HYDE PRATT

The State of North Carolina is divided into three physiographic divisions, which have been designated as the Coastal Plain, the Piedmont Plateau, and Mountain region. That part of the state lying to the west of the Blue Ridge is in the Mountain Region. This includes the Blue Ridge and the Great Smokies and the country between, which is cut across by numerous cross ranges separated by narrow valleys and deep gorges. The average elevation of this region is about 2,700 feet above the sea level, but the summits of a great many ridges and peaks are over 5,000 feet, while a considerable number of peaks have a height of over 6,000, the highest of which is Mount Mitchell with an elevation of 6,711 feet. Over the larger part of this region are to be found the older crystalline rocks, gneisses, granites, schists and diorites that are pre-Cambrian age which are greatly folded and turned on their edges. On the western and eastern borders of this mountain region, approximately along the line of the Blue Ridge and Great Smokies, there are two narrow belts of younger sedimentary rocks, consisting of limestones, shales, and conglomerates, and their metamorphosed equivalents, marbles, quartzites, and slates of Cambrian age.

The sedimentary rocks have been formed from sand, gravel, and mud which have been deposited as the result of alteration and erosion of the older rocks.

By the present position of the rocks we are able to obtain records regarding the order in which the rocks of western North

Carolina were formed, and thus obtain a geological history of the mountain section. All the rocks of western North Carolina are amongst the oldest geologic formations, although there is considerable variation in the time at which the various rocks encountered were formed. The oldest rock formation is known as the Carolina gneiss, which consists of large areas of mica and granite schists; and mica, granite, and cyanite gneisses. The exact origin of this rock has not been definitely determined; it may have resulted from the metamorphism of a granite rock. Mount Mitchell and the other mountain peaks of the Black Mountains are of Carolina gneiss, as are also Grey Beard, The Craggies, Sunset Mountain, Pisgah, Great Hogback (Toxaway), and Standing Indian (Clay County).

The next oldest rock formation of western North Carolina is known as the Roan gneiss, which is not as extensive as the Carolina gneiss, but forms much smaller areas and, as a rule, forms long narrow bands cutting the Carolina gneiss. They are also much less altered and are undoubtedly younger. Roan, High Knob, Big Yellow Mountain, Cocks Knob, the eastern slope of Craggy Dome and Bull Head Mountain, Nofat Mountain, and part of Cæsar's Head, are all of Roan gneiss. These mountains are, therefore, younger formations than those mountains composed of Carolina gneiss.

Another granite formation has been intruded into the Carolina and Roan gneisses, forming rather small areas in the northwestern portions of the mountains. These granites, known as the Cranberry and Beech granites, are observed in the vicinity of Blowing Rock, Beech Mountain, Rich Mountain, and part of Pumpkin Patch Mountain. A similar granite, known as the Henderson granite and of approximately the same age, is found over a considerable area of southeastern portion of Transylvania and Henderson counties and southwestern portions of Buncombe County.

All these rocks referred to above are of deep-seated origin and the lapse of time between the formation of the different ones was undoubtedly very great. They formed mountain ranges that were much higher than now observed, but these have

been subject to erosion which has brought them to their present outline.

The next formation was the lava rocks, which were poured forth upon the surface of the Archean rocks. These lava flows are of considerably later period than the granites and gneisses and are older than the overlying Cambrian sedimentary rocks, and they may belong to the Algonkian age. Some of these rocks were undoubtedly of volcanic nature, the intrusions coming to the surface as flows of lava and spreading out over the Carolina and Roan gneisses and the Cranberry and Beech granites. There was a very long interval between the formation of the last of the Archean rocks before the volcanic activity; and during this period these old Plutonic rocks were subject to very excessive erosion. This volcanic activity probably extended into the Cambrian time, and many of the lava flows were probably at the surface when the Cambrian strata were laid down. The indication of this is the finding of sheets of basalt conglomerate interstratified with the lower strata of the Cambrian. Rocks of this period include meta-diabase, found just north of Linville and to the east in Grandmother Gap and crossing the Yonahlossee road at several places; blue and green epidotic schists, which have been probably altered from basalt, such as are to be seen in the vicinity of Pineola and Montezuma, Avery County, and Hanging Rock, Caldwell County; a gray and black schist probably formed by the alteration of an andesitic rock, which is to be observed on Flat Top Mountain and Pine Ridge, Watauga County; and metarhyolite, such as is found on the slopes of Dugger Mountain, Sampson Mountain, and in Cook's Gap, Watauga County.

These Archean rocks, with the volcanic formations, were then subjected to a long period of erosion, and the sea at the same time encroached upon large areas of the dry land. The sediments deposited formed the rocks which are known as the Cambrian. Portions of the Archean rocks were submerged and at times uplifted, and there was not a continuous series of these sedimentary deposits.

These sedimentary rocks, formed from the erosion of the Archean and Algonkian rocks and from siliceous and calcareous

material deposited from animal life found in the sea, consist of conglomerates, sandstones, shale, limestone, and their metamorphic equivalents, quartzite, slate, and marble. These are observed very extensively over considerable areas of western North Carolina, but principally, as stated above, near the western and eastern sections of the mountain region. Grandfather Mountain is composed of one of these conglomerates of Cambrian age, as is also Grandmother Mountain, a large part of the area around Linville, and just to the east of Pineola. A narrow strip of these rocks is to be found extending across the extreme western part of Buncombe County, across Henderson and Transylvania counties. Brevard is situated in an area of these rocks, as is also Boylston, Mills River, and Fletcher, Henderson County. Practically all of Cherokee and Graham counties is composed of Cambrian rocks and the western parts of Clay, Macon, and Haywood counties. Swain County is composed largely of these Cambrian rocks, with the exception of an area of Archean rock that is exposed around Bryson and for some distance to the northeast. West of Asheville these Cambrian rocks are observed in the vicinity of Stackhouse, Hot Springs, and Paint Rock. They include all the limestones, such as are being mined at Fletchers, Mills River, and other places in Henderson and Transylvania counties; the limestones of Madison County; and the marbles of Cherokee, Graham, and Swain counties.

From the above it will be seen that the larger part of the area of western North Carolina is composed of the Archean rocks, representing the oldest rock formations.

Associated with the rocks described above are various minerals of economic importance, the history of which may be of interest in connection with the geological history of western North Carolina. The precious metals occur very sparingly in nearly all the counties of this section of the state, and in only a very few places has any attempt been made to systematically produce them, and this has been largely by placer mining. Both the rocks of the Archean and Cambrian age apparently contain minute quantities of gold, but in none of these have deposits been found of sufficient richness to be profitably mined. In the early history of western North Carolina it was customary

for many of the inhabitants to pan the various streams for gold and to pay their taxes in native gold. Just how much gold has been taken from western North Carolina in this way is not known; but it evidently runs up into several hundred thousands of dollars.

Iron was discovered in western North Carolina almost as soon as the country began to be settled, and the manufacture of iron dates back before the Revolutionary War. These early iron works consisted of the primitive Catalan forge blown by the water trompe. Such forges were in operation in Ashe, Mitchell, and Cherokee counties, and as late as 1893 one of these, the Pasley forge on Helton Creek in Ashe County, was in operation. These early forges supplied iron for all local uses and the forges in Cherokee County shipped a good deal into Tennessee. The most celebrated iron mine of western North Carolina is the Cranberry, and this iron was worked in Catalan forges as early as 1820. The following facts regarding the Cranberry iron may be of interest:

*"Cranberry Bloomery Forge, on Cranberry Creek; built in 1820; rebuilt in 1856; two fires and one hammer; made 17 tons of bars in 1857.

"Toe River Bloomery Forge, situated 5 miles south of Cranberry forge; built in 1843; two fires and one hammer; made about 4 tons of bars in 1856.

"Johnson's Bloomery Forge, 6 miles east of south from Cranberry; built in 1841; had two fires and one hammer; made 1½ tons of bars in 1856."

This ore made an excellent quality of iron and soon became known and attracted a great deal of attention throughout the United States. Since 1882 the mine has been worked almost continuously. Similar grades of iron ore are found in Ashe County, and the following is a summary of the history of the Catalan forges that were operated on these Ashe County magnetic ores:

"The Pasley forge was built by John Ballou at the mouth of Helton Creek in 1859; in 1871 it was rebuilt by the present owner, W. J. Pasley, and is now sadly in need of repairs.

"Helton Bloomery Forge, on Helton Creek, 12 miles N. N. W. of Jef-

*From "The Iron Manufacturer's Guide," 1859, by J. P. Leslie.

ferson; built in 1829; two fires and one hammer; made in 1856 about 15 tons of bars. Washed away in 1858. Another forge was built 1¼ miles lower down on the creek in 1802, but did not stand long.

"Harbard's Bloomery Forge was situated near the mouth of Helton Creek; built in 1807 and washed away in 1817.

"Ballou's Bloomery Forge was situated 12 miles N. E. of Jefferson, at the falls of North Fork of New River; built in 1817; washed away in 1832 by an ice freshet.

"North Fork Bloomery Forge was situated on North Fork of New River, 8 miles N. W. of Jefferson; built in 1825; abandoned in 1829; washed away in 1840.

"Laurel Bloomery Forge, on Laurel Creek, 15 miles west of Jefferson; built in 1847; abandoned in 1853.

"New River Forge, on South Fork of New River, ½ mile above its junction with North Fork; built in 1871; washed away in 1878."

The brown hematite ores of Cherokee County which occur in the Cambrian rocks were worked in forges as early as 1840, supplying the surrounding country with bar iron. We have record of the following forges:

"Lovingood Bloomery Forge, situated on Hanging Dog creek, 2 miles above Fain forge; built from 1845 to 1853; two fires and one hammer; made in 1856 about 13 tons of bars.

"Lower Hanging Dog Bloomery Forge, on Hanging Dog Creek, 5 miles northwest from Murphy; built in 1840; two fires and one hammer; made in 1856 about 4 tons of bars.

"Killian Bloomery Forge, situated ½ mile below the Lower Hanging Dog forge; built in 1843; abandoned in 1849.

"Fain Bloomery Forge, on Owl Creek, 2 miles below the Lovingood forge; built in 1854, two fires and one hammer; made in 1856 about 24 tons of bars.

"Persimmon Creek Bloomery Forge, situated on Persimmon Creek, 12 miles southwest from Murphy; built in 1848; two fires and one hammer; made in 1855 about 45 tons of bars.

"Shoal Creek Bloomery Forge, situated on Shoal Creek, 5 miles west of the Persimmon Creek forge; built about 1854; one fire and one hammer; made in 1854 about ½ ton of bars."

With the exception of the blast furnace at Cranberry which uses the magnetic iron ore from the Cranberry mine, no other furnace has been erected in western North Carolina for the treatment of iron ores; and when the Pasley forge on Helton Creek went out of commission, there was no other point in west-

ern North Carolina, except the Cranberry, where iron was being made. A small amount of ore has been shipped from time to time from various localities.

Copper mining at one time was a prominent industry of western North Carolina; and while I have no definite data as to when copper mines were first operated in western North Carolina, we do know that copper properties were worked before the Civil War, principally in Ashe and Alleghany counties. The most noted mine was the Ore Knob, which is in the southeast corner of Ashe County near the top of the Blue Ridge and about two miles from New River. This mine was first opened sometime before the War, but it was not until some years after the war that it was developed to any great extent. The ore deposit was worked to a depth of 400 feet by means of numerous shafts and drifts. The mine was equipped with a smelter for producing a high grade of copper. The amount of copper produced and shipped from January, 1879, to April, 1880, which was the time the mine was fully operated, was something over 1,640 tons. The cost to produce and market this copper was $.1039 a pound. The mine has not been worked since about 1882. Other copper properties that were worked were the Copper Knob or Gap Creek mine in the southeast part of Ashe County; the Peach Bottom mine on Elk Creek, Alleghany County; the Cullowhee mine on Cullowhee Mountain, and Savannah mine on Savannah Creek, Jackson County.

Another mineral for which western North Carolina is noted is corundum. In 1870, Mr. Hiram Crisp found the first corundum that attracted attention to the present mining region of North Carolina, at what is now the Corundum Hill mine. A specimen was sent to Prof. Kerr, then State Geologist, for identification, and considerable interest was aroused when it was discovered that it was corundum. In the same year, Mr. J. H. Adams found corundum in a similar occurrence at Pelham, Massachusetts.

In 1870-71, much activity was displayed in the search for corundum in the peridotite regions of the southwestern counties of North Carolina, and new localities were soon brought to

light in Macon, Jackson, Buncombe, and Yancey counties. In 1871, Dr. Genth discovered the emery of Guilford County. About this time, Mr. Crisp and Dr. C. D. Smith began active work on the Corundum Hill property, and obtained about a thousand pounds of corundum, part of which was sold to collectors for cabinet specimens. Some of the masses that were found weighed as much as 40 pounds.

Systematic mining for corundum did not begin until the fall of 1871, when the Corundum Hill property was purchased by Col. Chas. W. Jenks, of St. Louis, Missouri, and Mr. E. B. Ward, of Detroit, Michigan, and work was soon begun under the superintendence of Col. Jenks. This was the first systematic mining of common corundum, as distinguished from emery and the gem varieties, ever undertaken, while the first mining of the emery variety of corundum in America was at Chester, Massachusetts. The Corundum Hill mine produced corundum almost continuously from 1872 to 1901. Other mines that have produced corundum are the Buck Creek mine in Clay County; the Ellijay mine in Macon County; the Carter mine in Madison County; and the Higden mine and Behr mine in Clay County.

Mica mining in North Carolina began about 1870, and for the first 5 years practically all the mica mined was handled by Heap and Clapp, and was obtained from the mines of Mitchell and Yancey counties. Mica has continued to be mined almost constantly since that time not only in Yancey and Mitchell counties, but in Ashe, Buncombe, Haywood, Jackson, and Macon counties. There are a great many old workings on these mica deposits and before they had been investigated and the mica discovered they were supposed to be old workings of the Spaniards who were hunting for silver. It is now supposed that these old workings were made by the Indians for these sheets of mica; and it is known that mica has been found in Indian mounds and was used by the Indians who inhabited what is now Ohio in the manufacture of their beads. North Carolina mica is still known as standard mica, as it was reckoned from the beginning.

Several other minerals should be mentioned in connection with the descriptions given above as they were first identified in North

Carolina. The mineral that stands out most strikingly is the rhodolite, a gem mineral which was discovered in Macon County about 1894 and was given its name from the resemblance of its color to that of certain rhododendron.

Mitchellite, a variety of chromite, was discovered near Webster, Jackson County, 1895, and was named in honor of the late Prof. Elisha Mitchell of North Carolina.

Wellsite, one of the minerals of the zeolite group, was discovered in 1892 at the Buck Creek mine, Clay County, and was named in honor of Prof. H. L. Wells, of Yale University.

The following, belonging to the vermiculite group of minerals, have been found associated with corundum, and were described by Doctor Genth; they were all discovered about the same time in 1872 or '73: culsageeite, a variety of jefferisite, found at the Corundum Hill mine and named for a postoffice near that place; kerrite, found at Corundum Hill mine, and named in honor of Mr. W. C. Kerr, former State Geologist of North Carolina; maconite, found at the Corundum Hill mine and named after Macon County; lucasite, found at the Corundum Hill mine and named after Dr. H. S. Lucas, who owned the Corundum Hill mine; and willcoxite, found at the Buck Creek (Cullakenee) mine, Clay County, and named after Joseph Wilcox of Philadelphia. Auerlite, found at the Freeman mine, Green River, Henderson County, about 1888, it is a thorium mineral, and was named for Dr. Carl Auer von Welsbach; hatchettolite, a tantlum-uranium mineral, was found at the Wiseman Mica mine, Mitchell County, about 1877, and was named after the English chemist, Charles Hatchett; phosphuranylite, a uranium mineral, found at the Flat Rock mine, Mitchell County, about 1879, and named from the chemical composition of the mineral; and rogersite, a niobium mineral, found at the Wiseman Mica mine, Mitchell County, about 1877, named after Prof. W. B. Rogers.

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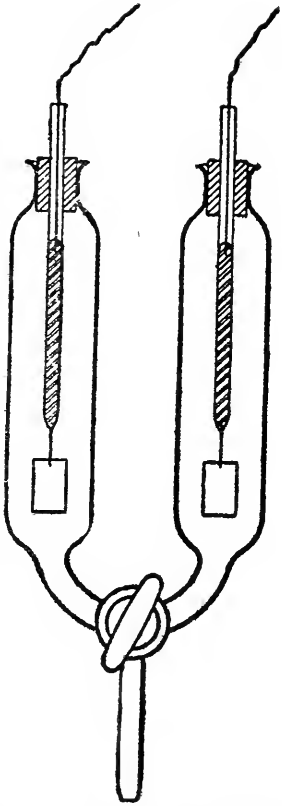
8 and 9 on the Mining Industry in North Carolina, 1901, 1904, 1905. U. S. G. S. Geologic Folios, Cranberry, 1903; Asheville, 1904; Mount Mitchell, 1905; Pisgah, 1907; Roan Mountain, 1907; Nantahala, 1907.

CHAPEL HILL, N. C.

ELECTROMOTIVE FORCE OF SILVER NITRATE CONCENTRATION CELLS*

BY JAMES M. BELL AND ALEXANDER L. FEILD

The electromotive forces of concentration cells — two aqueous solutions of silver nitrate between silver electrodes, $Ag/AgNO_3/AgNO_3/Ag$—have been measured by Miesler,[1] by Nernst,[2] by Negbaur,[3] by Cumming and Abegg,[4] and by Cybulski and Dunin-Borkowski.[5] Non-aqueous solutions have been employed in similar measurements by Bodländer and Eberlein,[6] by Neustadt and Abegg,[7] and by Roshdestwensky and Lewis,[8] the non-aqueous solvents being ethylamine, methylamine, methyl alcohol, ethyl alcohol, acetone and pyridine.



The present paper contains results of measurements of the electromotive force in aqueous solutions and in ethyl alcohol solutions over a wider range of concentrations than heretofore used.

The water used in making up the solutions was distilled several times and had a low conductivity. The ethyl alcohol stood several days over quicklime and was then distilled from barium oxide. Baker's analyzed silver nitrate was used, the impurities present being negligible in amount.

The cell is shown in the figure, and consists of a U-tube with outlet tube and

* Reprinted from the Journal of the American Chemical Society, Vol. XXXV. No. 6. June, 1913.

[1] *Monatshefte*, 8, 193, 365 (1887); *J. Chem. Soc.*, 52, 1073 (1887); 54, 13 (1888).
[2] *Z. physik. Chem.*, 4, 155 (1889).
[3] *Wied. Ann.*, 44, 737 (1891).
[4] *Z. Elektrochem.*, 13, 18 (1907).
[5] *Anz. Akad. Wiss. Krakau*, 1909, 660. *Chem. Zentr.*, 1909, II, 1295.
[6] *Ber.*, 36, 3945 (1903).
[7] *Z. physik. Chem.*, 69, 486 (1909).
[8] *J. Chem. Soc.*, 99, 2138 (1911).

three way stock-cock. While the cell was in the thermostat, the outlet tube was capped. The three-way stopcock permitted the removal of either solution, and permitted the separation of the solutions in the limbs of the tube until the measurement was about to be made. The electrodes were of platinum foil about 1 cm. square, welded to platinum wire which was fused through a glass tube containing mercury. Frequently during the course of the experiments, the platinum foil and wire were plated with silver from silver nitrate solutions acidified with nitric acid. When the two solutions were at the same level in the two limbs of the U-tube, connection between them was made by opening the stop-cock, and the E. M. F. was determined by the ordinary potentiometer method. The galvanometer was sensitive to 0.00005 volt even with a large resistance in the circuit. An electrically heated and electrically controlled thermostat was run at 25° constant to 0.01°. The measurements were irregular until the metal coating of the thermostat tank was grounded.

Measurements of the electromotive force of such combinations were constant within 0.0001 volt for at least 20 minutes after putting the solutions in contact. The table below gives the mean of two values obtained when different solutions and freshly plated electrodes were used. These duplicate measurements differed at most by 0.0003 volt and in the majority of cases by not more than 0.0001 volt.

TABLE I

	Mols/liter c_1	Mols/liter c_2	E.M.F. obs. Millivolts.	$K = \frac{E}{\log_{10} c_1/c_2}$
(1)	1.0	0.1	47.2	0.0560
(2)	1.0	0.01	103.6	0.0584
(3)	0.3	0.03	53.6	0.0606
(4)	0.3	0.003	113.8	0.0616
(5)	0.1	0.01	56.6[1]	0.0608
(6)	0.03	0.003	60.1	0.0623
(7)	0.01	0.001	60.2[2]	0.0623

These readings show satisfactory agreement among themselves, for the sum of (1) and (5) should equal (2), and the sum of (3) and (6) should equal (4). The differences are 0.0002 and 0.0001 volt respectively.

[1] Cumming finds 59.0 millivolts.
[2] Cumming finds 61.8 millivolts.

The Nernst formula for cells of this type is

$$E = \frac{2v}{u+v} \frac{RT}{nF} \log_e \frac{c_1}{c_2}$$

where c_1 and c_2 refer to the concentration of silver ions and not to the concentration of silver nitrate. It is necessary to know the values of u and v, the migration ratios of Ag^+ and NO_3^-. With solutions for which u and v are constant, values proportional to the ionic concentrations are given by the conductivities of the solutions, and these are inversely proportional to the resistance of the solutions. Cumming and Abegg conclude "that

TABLE II

Concentration.	Resistance.
1.0	3.486
0.3	9.646
0.1	24.25
0.03	73.80
0.01	206.49
0.003	679.32
0.001	1907.0

conductivity seems to be an exact measure of ion concentration." The preceding table contains the results of measurements of the resistances of the above solutions.

Measurements of the migration ratios at each concentration were not made. The table given by Lehfeldt[1] indicates that the migration ratio for silver nitrate is fairly constant up to a concentration of 0.2 mols per liter. Assuming this value to be constant the above becomes

$$\frac{E}{\log_{10} c_1/c_2} = \frac{2v}{u+v} \cdot \frac{RT}{nF} \cdot \log_e 10 = K.$$

The values of $K = \dfrac{E}{\log_{10} c_1/c_2}$ are given in the last column of Table I and with the exception of cells 1 and 2, where normal solutions were used, they are fairly constant. This confirms the results of previous investigations, which show that the

Nernst formula holds for dilute solutions of silver nitrate. From the value of K found above the values of u and v may be calculated by substitution of the proper values of the other quantities in the equation

$$K = \frac{RT}{nF} \frac{2v}{u+v} \log_e 10$$

Taking K=0.0623 the value of v is 0.523 while the observed value, given by Lehfeldt[1] is 0.528.

The table compiled by Lehfeldt indicates that the value of v is less for concentrated solutions and this would make the value of K smaller in proportion. The present results are in harmony with this fact, although it is impossible as yet to calculate the electromotive force between two solutions of silver nitrate of such concentrations that the migration ratio of the two are different.

The following table gives the results of measurements of the electromotive forces of three combinations where ethyl alcohol was used as solvent.

TABLE III

	Mols/liter c_1	Mols/liter c_2	E.M.F. obs. Millivolts.	$K = \frac{E}{\log_{10} c_1/c_2}$
(1)	0.1	0.01	47.0	0.068
(2)	0.1	0.001	106.6	0.071
(3)	0.01	0.001	59.7	0.074

The experimental values are consistent among themselves as the sum of (1) and (3) is 106.7 against 106.6 for (2).

The relative ionic concentration of silver ions was determined by conductivity measurements the results being given in the next table.

TABLE IV

Concentration.	Resistance.
0.1	208.5
0.01	1024.0
0.001	6420.0

Again assuming that at all the concentrations employed the values of the migration ratios remain constant, the value of K

[1] *Electrochemistry*, p. 256 (1904).

was determined by the same formula as for aqueous solutions. As these values vary somewhat (see Table III), it seems probable that the migration ratios of Ag^+ and NO_3^- are not constant even for concentrations below o.1*N*. Taking K=0.074, the value of v is 0.62.

SUMMARY

The electromotive forces of concentration cells containing solutions of silver nitrate in water at 25° are in accord with the Nernst formula for dilute solutions. Where higher concentrations were employed the calculated value of the electromotive force is greater than the observed because the migration ratio v is smaller at the higher concentrations. This affects two factors in the Nernst equation, *viz.*, $2v/u+v$ and log c_1/c_2. The latter factor is affected because the ratio of the ion concentrations c_1/c_2 is determined from conductivity measurements and this method of determination is valid only when the migration velocity remains constant. The value of migration ratio for dilute solutions calculated from the above results agrees closely with the values found by direct experiment.

For ethyl alcohol solutions the migration ratio apparently varies even at concentrations below o.1 *N*. The value of v calculated from the most dilute solution was 0.62.

CHAPEL HILL, N. C.

ANNUAL ADDRESS OF THE PRESIDENT OF THE NATIONAL ASSOCIATION OF SHELLFISH COMMISSIONERS, NORFOLK, VA., APRIL 23, 1913

BY JOSEPH HYDE PRATT

It is with a great deal of pleasure that I, as President of the National Association of Shellfish Commissioners, respond for the members of the Association and delegates to this convention to this most cordial welcome that has been extended to us. I can assure the good people of the city of Norfolk and of the State of Virginia that it is very gratifying to us to be able to hold this fifth annual convention of our Association in the old historic State of Virginia, which has always stood in the foreground of progress, and has played such a vital and important part along all lines in the development of our great nation. The warm, sincere, and open-hearted hospitality for which Virginia has always been noted, is now being extended to us. There are but very few instances in the history of this great State where this warm and open-hearted hospitality has not been shown to those who desired to come within her borders, such as: the refusal of the State to accept certain governors that England wished to force upon her; the warm but inhospitable reception that was extended so effectively to Cornwallis and his followers during the Revolutionary War; and the polite and energetic request that was given to certain visitors who insisted on coming into the State during the sixties that their room was preferable to their company. I believe, outside of such instances as I have mentioned, that Virginia has at all times extended the right hand of fellowship and free hospitality to all who wish to come and visit or dwell within her borders. Even those whom she turned away on account of certain differences have, when the differences became adjusted, been and are now being received with the same sincere cordiality as if these differences had never existed.

We cannot, as we meet together in this State, prevent ourselves from reminiscing regarding the early history of Virginia; from

the spring of 1607, when the first permanent English colony was established at Jamestown, Va.; and, as we do this, we realize that to the men who assisted in the building up of this colony and to all Virginians who have followed, even to perhaps the greatest of all, who now occupies the highest office in the gift of the people,—President Woodrow Wilson,—that to these men the nation is indebted for much of its success and its rise to the greatest nation in the world.

It can be truthfully said that not only in the United States but also in our own States individualism and sectionalism, as opposed to a national or state community spirit, has reached in the past few years a point that is of positive detriment to the best growth and development of our country. We believe, however, that we now have at the head of our national government a broad-minded, conscientious man whose attention is directed to measures of nation-wide importance, which he will endeavor to see are considered in a manner that will be for the best interest of the country at large, and not for the benefit of any particular local section or community or interest at the expense of the country as a whole. I believe that the influence of this man is going to be wide-spread throughout the nation, so that various measures that are coming up in the states will be considered from the standpoint of the State, and not from the standpoint of the county or township. It is undoubtedly true that questions that come up relating to the conservation and perpetuation of our natural resources of whatever character they may be, must be considered from at least a state, and in some cases a national standpoint, if the best results or even any good results are to be obtained; and this is very true in connection with the shellfish industries.

Virginia is one of the few South Atlantic States that has taken a decided practical step looking toward the conservation and perpetuation of her shellfish industry, and through the conscientious work of her able commissioner, Hon. W. McDonald Lee, she has reached the place where she can point with pride to what the State is accomplishing in the oyster industry. Her Lynnhaven and James River oysters are famous not only in the

State but throughout the country, and she has made them abundant so that she can supply the greatest demand that may arise for them. I have used the words "made them abundant" advisedly, inasmuch as the results accomplished have been due to the actual work of man in the cultivation and planting of the oyster as well as assisting by adequate statutes the growth and reproduction of the oyster on the natural rock. The oyster industry is on a paying basis, and each year is enabled to pay into the General Treasury of the State a very satisfactory fund, after all expenses have been met. This could only have been accomplished as a state-wide measure.

Man himself is one of the most important factors in decreasing the supply of oysters and other shellfish in the waters of the several states, due largely to his selfish interest and to his idea that anything that comes out of the sea is his by a God-given right, and that the State has no authority over it whatever. Many of the natural oyster rocks or reefs may have been partially or wholly destroyed by becoming muddied or sanded, due to very severe storms, thus smothering the oysters; or the beds may have been destroyed by some parasite; or, because of the certain changes of the coast line, waters may have become too fresh; and thus the natural rocks have been destroyed. Notwithstanding the fact that these causes may account for the destruction of many natural rocks, it is undoubtedly true that the most important influence is the one that has to do with the actual taking of the oysters themselves. This is especially true of the lobster, which in many sections has been almost entirely exterminated by overfishing. The oyster and the clam have practically no chance whatever to protect themselves or to escape their worst enemy, man; but, though an enemy, it is also through the efforts of man that the destruction wrought in many places must be and has been remedied. If it had not been for the conservationist or perhaps I might say in connection with the oyster industry, the man who appreciated the oyster as a delicious food, realizing that unless some steps were taken by the State or National governments to protect it and prevent over-oystering of the natural rocks, the oyster would be exterminated; we would be today in many, if not all of the

states, without this form of food. There were such men who came to the assistance not only of the oyster but of other shellfish. In many instances, however, it would have been too late with the oyster if it had not been previously demonstrated that its cultivation was a commercial proposition, and this had been taken up very extensively in those states where the natural rock had been very nearly depleted. Besides producing oysters on the made rock, another result of the cultivation of the oyster has been that the natural rocks have in several states begun to increase and become again very productive, which is undoubtedly due to the great quantity of spat that was produced by the cultivated beds, and which settled on the natural rocks.

Such recommendations as are made for the perpetuation and cultivation of the oyster and the protection and perpetuation of other shellfish can only be carried out by a state's taking the problem and considering it as a state proposition. Where this has been done the results have been most beneficial and gratifying, and the oyster industry of these states has been revived and become a very profitable one. There are, however, still many states where the problem has not yet been successfully solved; and it is found, upon investigation, that the reason for this is that state legislators have not and are not now considering the question as a state problem, but are permitting the local communities to have enacted laws relative to the oyster industry, and are not taking any steps from the standpoint of the state for the protection of these shellfish. The result is, that in several of the states, as: North Carolina and Georgia, oystering has reached a very low ebb, so low in fact that it is scarcely to be reckoned with in considering the oyster industry of this country.

The work of this Association is to consider and assist in the solving of all problems that may come up in regard to the perpetuation of the various shellfish; and it has tried and is still trying to bring every state that has shell fisheries to a realization of the absolute necessity of the state taking up the problem and passing adequate legislation covering the whole industry in the state. The Association has had the hearty co-operation of the United States Bureau of Fisheries in this work, and we believe that the considerable progress that has been made in the

shellfish industry can be directly traced to the work of this Association.

With the passage of adequate laws regulating the fishing of the oyster, and its cultivation, problems immediately come up that must be considered and solved, such as:

What are natural rocks?

What areas shall be open for cultivation of the oyster?

Shall such areas be leased or sold?

How much area shall each individual be permitted to take up?

How shall the oyster bottoms be taxed?

What regulation shall be made in regard to the production and shipment of seed oysters?

What measures shall the State take to protect the beds that are being cultivated; for the protection of the natural rock?

Pollution of oyster rocks and its prevention.

Effect of dumping all waste material into our harbors and bays which may result in the pollution of oyster rocks and clam beds, or may cover the oyster rock and thus smother the oysters.

Shall the areas of the natural rock be mapped or the areas that are leased or sold for cultivation?

Uniform seasons for catching oysters in adjoining states.

The solution of these problems is now being taken up by the various states and also the Federal Government; and they are slowly but surely being solved, and we believe in the interest of the shellfish industries.

As can readily be seen from these problems, it will be absolutely impossible to solve them unless it is done by the states as state propositions. The problems vary in the different states and in some that relating to the oyster has been almost entirely solved, but there still remains a great deal to be done in connection with the perpetuation of other forms of shellfish. The necessary measures that are required to better the various shellfish industries will be accomplished just so fast as we are able to educate those who make a livelihood out of these industries, as to the need of conservation; bring the rest of the people of that particular state to a realization that they too have a decided personal interest in the conservation of these industries; and

cause each of these classes of people to realize that the shellfish do not belong to the individual but to the state, and, therefore, the state has a right to insist upon their protection and perpetuation.

The National Association of Shellfish Commissioners is trying to bring together the best information obtainable regarding the problems suggested above; and they are holding conventions to discuss these problems and work out, if possible, a plan which will eventually solve them. The information at our conventions has been of very great assistance to the commissioners of the various state, and is being utilized by them for the good of the industry.

Some states are better equipped than others for carrying on experimental work in connection with certain problems, and, although the results of their experiments are of peculiar value to that state, yet they are of great value to all who are interested in the same or similar problems to those that have been investigated. Our Association should be and is a clearing house through which each State Commission can obtain the benefit of the results obtained by the others.

The discussions that have taken place at our previous conventions on such subjects as:

The leasing vs. the sale of sea bottoms for oyster and clam cultivation;

The method and rate of taxation of oyster and clam bottoms;

The pollution of oyster bottoms;

have all been of very great interest, and the fervor and earnestness with which the delegates to the convntion entered into the discussion resulted in the co-ordination of our ideas and theories, and emphasized the value of co-operation.

We sometimes become impatient at the length of time required to have our ideas, suggestions and recommendations put into practice by our state legislators, and we wonder why they can be so ignorant on such an important subject, as the "Shellfish Industry." Yet we cannot expect them to be very familiar with a subject that has taken us years to understand and realize its great value. What we do, however, have a right to become impatient over is the often apparent unwillingness of our legis-

lators to accept the recommendations of the Shellfish Commissions regarding the industry or that their ideas are of any particular value; and instead pass legislation regarding the industry that is almost diametrically opposite to our suggestions. This is frequently done for political reasons, and the interests of the state have been sacrificed for self advancement. I believe, however, the tide is turning and that we are entering upon an era when man's love of country and his true patriotism will outweigh the thought of self; and in deciding questions of state his query will be: What effect will this measure have upon the country and upon my state, and not what will be the political effect upon me. When we have broadened and developed to such an extent that we consider in these great questions first, our country's interest, then our state, then our county, and last our own individual community, then and then only, will we be able to obtain the best solutions to these problems.

Our co-operation should not only be between the states but between the states and the U. S. Bureau of Fisheries. There should be a more adequate appropriation made by Congress to the Bureau of Fisheries for investigations relating to the shellfish industry. There is a wide field for work which should be done largely by the Federal Government, and in co-operation with the several states. The importance and value of the industry warrant our making a vigorous demand upon Congress for such an appropriation.

The oyster, clam, scallop, the lobster, the crab and the terrapin must all receive the attention of the Shellfish Commissions.

The sessions of our convention are open to the public and we will gladly welcome any who are interested enough in the subject to attend; and we may in this way impress upon laymen the value and importance of the industry we represent.

In closing, I wish to express to you Virginians our extreme regret that illness has kept Governor Mann from meeting with us. We miss his word of cheer and guidance, and voice with you the prayer that his illness may not be for long, and that he will soon be restored to his State in full vigor and health.

CHAPEL HILL, N. C.

LIME ON SOILS

BY JOHN E. SMITH

The various operations of tillage are performed for the purpose of enabling the plant to obtain the food necessary in the process of growth. Certain substances are sometimes added to the soil to increase its productivity; these are known as soil amendments and lime is one of the most useful of them.

CORRECTS THE ACIDITY

An acid condition results from the decay of organic matter, is brought to the top soil from the subsoil by capillary water, is produced by nitrifying bacteria, and is formed in other ways. All forms of lime (except gypsum) readily counteract or neutralize this condition, one ton per acre in most cases being sufficient to keep the soil neutral for two or three years.

AIDS NITRIFICATION

The acidity of soils is somewhat injurious to the growth of many plants and in many instances is fatal to the legumes (clover, vetch, alfalfa, etc.), whose power to assimilate and store nitrogen is dependent on the activity of bacteria that thrive in a neutral or slightly alkaline soil but cannot live in the presence of much of the acidity which in part is the product of their own work. A supply of lime in the soil neutralizes the acid as rapidly as it is formed and thus prevents its accumulation and maintains a condition favorable to the rapid growth of nitrifying bacteria. Lime is therefore essential to the successful growth of leguminous plants sooner or later.

IMPROVES THE STRUCTURE

By structure of the soil is meant the arrangement or grouping of the soil particles. This is very intimately related to pore space, water holding capacity, and to the movements of soil moisture.

The addition of lime to clay soils is a strong factor in preventing cloddiness and in producing that most desirable granular, crumb-like structure which constitutes "good tilth," so

necessary in retaining the moisture in the soil during dry weather. It also increases the permeability of the soil for air. Nearly all forms of lime readily improve the soil structure.

For sandy soils a small amount of lime carbonate will serve to make the structure slightly more compact by cementing some of the particles together, thereby improving the power of the soil to hold capillary water and preventing its drying so readily.

FORMS OF LIME

In nature the chief source of "lime" is the common mineral calcite which occurs extensively as beds of fossils shells, often not distinguishable, and these beds according to their purity, the degree of consolidation, method of deposition, subsequent changes, and to the kind and nature of the contributing organisms, are classified as limestones, marls, chalk, marble, etc.

This material is applied to the soil in three forms; decayed limestone, marl, etc., these substances ($CaCO_3$) ground, and that which has been burned at a high temperature. In the process of burning, a gas (carbon dioxide, CO_2) is given off and calcium oxide (CaO), quicklime, remains. When quicklime is allowed to slack slowly in dry air, it again assumes the form of a carbonate and is called air-slaked lime. If water be added to the quicklime, the mixture forms calcium hydrate, $Ca(OH)_2$, and is known as water-slaked or hydrated (caustic) lime. If the slaking take place in damp air, the quicklime absorbs from the air some moisture and some carbon dioxide the result being a mixture of lime carbonate and hydrated lime.

Related Forms.—Dolomite is a calcium magnesium carbonate ($CaCO_3$, $MgCO_3$), sometimes incorrectly called magnesian limestone. It occurs extensively in the Appalachian Mountains and is found in Virginia, Tennessee, North Carolina, Georgia, and Alabama, where it is frequently called "marble."

Gypsum, the hydrated sulfate of calcium ($CaSO_4$, $2H_2O$), is ground and sold on the market as "Land Plaster."

TABLE OF EQUIVALENTS

Quicklime CaO		Hydrated lime $Ca(OH)_2$		Dolomite $CaCo_3$, $MgCO_3$		Pure, ground limestooe $CaCO_3$		Marl 85% $CaCO_3$		Marl 75% $CaCO_3$		Marl 60% $CaCO_3$
56 lb.	=	74 lb.	=	92 lb.	=	100 lb.	=	118 lb.	=	133 lb.	=	167 lb.
.75 ton	=	1 ton	=	1.24 ton	=	1.35 ton	=	1.59 ton	=	1.8 ton	=	2.26 ton
1 ton	=	1.35 ton	=	1.64 ton	=	1.78 ton	=	2.11 ton	=	2.38 ton	=	3 ton
$1.78	=	$1.35	=	$1.09	=	$1.00	=	$ .85	=	$ .75	=	$ .60

100 lbs. of pure limestone will produce when burned, 56 lbs. of quicklime which, when air-slaked, becomes 100 lbs. of finely powdered lime carbonate. If the 56 lbs. of quicklime be water-slaked, it unites with 18 lbs. of water to form 74 lbs. of hydrated lime. 100 lbs. of ground limestone contains the same amount of lime as 167 lbs. of 60% marl; one ton of hydrated lime is equal to three-quarters of a ton of quicklime and to two and one-fourth tons of 60% marl. If a given amount of ground limestone (one ton for example) is worth $1.00, the same quantity of 75% marl is worth (by weight) $.75, and of hydrated lime, $1.35. This however does not indicate the relative values of their effects on the soil.

ADAPTATION OF FORMS

Gypsum.—This form of calcium does not neutralize the acidity of the soil but on the other hand tends to increase it and should not therefore be used except on neutral or alkaline soils and then only in small quantities. It frequently changes some of the potash of the soil to the soluble form and sometimes makes more phosphorus available for the use of the plant.

In its effects on soil structure it decreases the rate of movement of capillary water and consequently reduces evaporation from the surface (in sandy soils 27%, King, The Soil, p. 177).

Gypsum accelerates the process of nitrification more than any other known substance. Its relation to lime in this respect may be seen in the following figures: lime carbonate, 13.3; gypsum, 100 (Hilgard, Soils, p. 147). It should be used on soils for this purpose only.

Dolomite.—This rock when ground very fine and applied to the soil has much the same effect as the lime carbonate especially on the first two or three crops following its application.

Later by successive additions of it to a field, the magnesia might be increased to an injurious extent, but this could be avoided by the occasional use of lime carbonate. Companies quarrying this material might utilize some of their wasted stone dust by selling it for this purpose. The burned dolomite is strongly caustic and should not be put on the land.

Hydrated Lime.—This form greatly hastens vegetable decay and often causes waste leading toward exhaustion of the organic content of the soil. When it is applied therefore, more organic matter such as barnyard compost, legume crops, etc., must be added except on soils containing peat, etc.

It corrects the acidity of the soil more quickly than other forms of lime and may produce a better increase in the yield during the first two or three years. For this reason it is frequently used by tenants.

On heavy clay soils this form is the most effective in producing a good granular, crumb-like structure and thus aids in the retention of moisture near the surface.

Lime Carbonate.—Ground limestone readily corrects the acidity of the soil, assists greatly in producing a condition favorable to the growth of nitrifying bacteria, and directly or indirectly renders available other plant foods such as phosphoric acid and potash. It changes vegetable materials into neutral humus at once and concentrates their nitrogen.

A liberal supply of lime carbonate added to orchard lands will increase the sweetness of the fruit (grapes included) if the lime was previously deficient in amount.

Lime carbonate greatly increases the flocculation of soil particles into granules and thus improves the texture of the soil.

Lime carbonate is useful in nearly every way in which lime is valuable as a soil amendment.

SUMMARY AND CONCLUSIONS

Under average conditions plants use annually nearly half a ton of lime carbonate per acre.

The effectiveness of lime added to the soil depends very largely on its fineness of grain (texture) and on its being thoroly mixed with the soil.

The finest grained limes are the air-slaked and the hydrated forms.

Unground limes and marls should be extremely well decayed.

The degree of acidity present and the amount of plant food in the soil determine the amount of lime to be used.

One or two tons per acre applied every two or three years is much better than larger amounts added at longer intervals.

Lime should be shipped in its most condensed form (quicklime) and hydrated on the farm where it is used.

Ground lime should be applied in the summer or fall to be available for the next spring crop. Hydrated lime is put on (do not mix it with phosphates) about a month before seeding.

The limestones and most of the marls of the Atlantic and Gulf Coastal Plains are desirable for use as ground material.

In Europe and America nearly all of the experiments conducted to test the relative value of ground limestone and the hydrated lime as amendments to soils deficient in lime, have produced results favorable to the lime carbonate.

CHAPEL HILL, N. C.

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DETAILS OF ARRANGEMENTS AND ORGANIZATION FOR THE USE OF CONVICT LABOR IN ROAD CONSTRUCTION

BY JOSEPH HYDE PRATT

Before taking up a discussion of the details of arrangements or organization for the use of convict labor in the construction of public roads, I wish to state briefly certain phases of the convict labor problem that are pertinent to the economic use of such labor. There are certain fundamental principles that must be borne in mind in considering this problem and in the handling of convict labor:

First: The convict is a human being and must be treated as such; he has a sense of responsibility, honor and discipline, and this sense can be quickened and developed.

Second: That perhaps with few exceptions, there is some good in every convict, which can be developed and made paramount in the character of the man.

Third: The convict in serving his sentence is simply paying a debt that he owes to the State for certain infringements of the laws of that State; and, when he has served this sentence, he has paid his debt and should be in a position to become a good and valuable citizen of the State. Most convicts are serving a first sentence and often for a crime committed on the spur of the moment, and with many of them this one crime committed represents the only black spot in their lives.

Fourth: Hard work is a good reformer, and idleness begets melancholia.

Fifth: The State on her part owes it to the convict to assist him in every way to pay his debt as speedily and economically

as possible, and in such a way that he is a better man when his debt is paid than when he was convicted.

Sixth: The attitude of the State toward the convict should be corrective and not vindictive; to uplift and not degrade him.

Seventh: To put a man in stripes often so degrades and humiliates him that it is extremely hard, and sometimes impossible, for him to reform.

Eighth: Outdoor work is much more conducive to good health and cheerful dispositions than confinement in prisons or factories with no outdoor exercises but what can be obtained in a limited area of a penitentiary yard or court.

Ninth: There must be an incentive before good work can be expected from most convicts.

Tenth: There is a great variation in the character and working ability of different convicts.

Eleventh: In many cases families were dependent upon the convict before his sentence and are, during his sentence, deprived of that support.

The first question that presents itself is whether the attitude of the State toward the convict should be to impress upon him that he has committed a wrong and therefore there is no good in him, and that this idea must be impressed upon him continually during the serving of his sentence; or whether the attitude of the State shall be that the convicted man in serving out his sentence is paying a just debt to the State, and that, while she insists the debt shall be paid and that in paying it the convict shall not forget that he is a debtor to the State, yet he may be able to eliminate as far as possible the fact that crime has been committed. Is it possible for the State to have this latter attitude toward the convict when they compel him to wear stripes—which in America universally denote the felon—have their heads shaved, and always walk in lock step when going from one part of the prison ground to another? These phases of a convict's life were formerly considered necessary in order to prevent his escape and were also considered as part of his punishment. They are degrading, and will wear out the

soul of many a man; and, to my mind, should only be used as a last resort and not as a first resort. I believe depriving a man of his liberty and requiring him to work for the State for a certain length of time according to the gravity of his crime is sufficient punishment for a very large majority of the men who are convicted.

At present, without going into the question as to what is the best work for the convict to do, I wish simply to make the general proposition that in any group of convicts it will always be found that some will do a great deal more and better work than others, that some will work very willingly and industriously; while others are lazy and only work the minimum amount that is required of them. This is especially true of a certain class, when they feel that they have got nothing whatever to gain by more energetic endeavors. Would it not then be the proper thing for the State to allow the convict a certain percentage of the value of his labor, which could be forwarded to his family, if he has one dependent upon him; or become accumulative and be given to him at the end of his sentence as a fund with which to start life anew.

The State is the guardian of every convict and she can make or break him according to the treatment she measures out to him. Her rules and regulations must be just, and then she must insist upon their strict obedience. On the other hand she must be just as strict to see that those she places in charge of the convict, whether it be Prison Warden, Superintendent, or Foreman, all keep faith with the convict and that all promises made to them of whatever character are kept. A promise to the convict is an obligation that the State must keep, and upon the strict carrying out of such promises and the strict enforcement of just rules and regulations will depend the success of the use of convict labor not only in road construction but for any other purpose.

Keeping in mind the suggestions and statements made above, I would submit for your consideration as a logical plan for the treatment and organization for work of the convict the following:

That the men who have been convicted and sentenced for the

first time all be considered as men capable of being treated in the most lenient way by the prison authorities. That they shall not be required to wear stripes or have their heads shaved, reserving this form of prison garb for those whom it is found cannot be trusted, and who will not live up to the rules and regulations of the prison authorities.

There could be three classes of convicts: Those in the *First Class* who are not required to wear startling or very noticeable uniforms; those in the *Second Class* who are required to wear a distinctive uniform but not stripes; and those in the *Third Class* who are required to wear stripes and, if necessary, have their heads shaved.

To the Third Class would be assigned those who have been convicted and sentenced more than once for some crime against the State, and those who, while serving out their sentence, are constantly breaking rules and regulations of the prison authorities.

To the Second Class would be assigned those who have started in the First Class but have shown that they will not obey all the rules and regulations or do good or efficient work and are not to be trusted; and for further infringement of the rules and regulations, they would be assigned to the Third Class. To this Second Class would come men from the Third Class who have shown by their work and their deportment that they are trying to live up to the rules and regulations and become better men. They in time might be able to be transferred to the First Class.

To the First Class would be assigned those who have been convicted for the first time, and they would remain in this Class until they have shown by their behavior that they are not to be trusted or will not do good and efficient work, when they will be assigned to the Second Class. In this First Class would be the men who would be known as "honor men."

In the South where a very large proportion of the men convicted of crime are negroes, it may not be possible to carry out exactly the above classification, as it may be necessary to assign the negro convict to the Second Class and make him show by his work and deportment that he is entitled to a place amongst the

"honor men." In the West and probably in the North where the negro convict is in the minority, it is possible to assign them at once to the First Class. To some it may seem that guns are necessary to control the negro convict, yet I believe it will be found possible to create in his mind the idea and realization that the serving out of his sentence is simply paying a just debt that he owes to the State, and that the State is really trying to better his condition and give him a chance to make something of himself again; and that this will develop in him a loyalty to the superintendent of the camp and the foreman under whom he works.

The convict force will be divided into the above classes regardless of the work that they are to do. The present paper, however, takes up the question of the use of this labor in the construction of public roads, which means the erection at various points of convict camps.

ORGANIZATION OF THE CONVICTS

The organization of this convict labor for road construction will be of two distinct methods depending upon the classes of convicts used:

First, would be the convicts that would be worked without guards and without stripes, representing the men of the First Class or "honor men."

Second, would be those over whom it is necessary to have armed guards while they are working, and would be convicts of the Second and Third classes.

The men of the Third Class would wear stripes and work under guards with guns, and the worst men of this class might have to be worked in stockades in breaking rock or doing similar work. Those of Class II would be worked under guards with or without exposed firearms, as the case might be. At night the convicts of Class III would be on chains and under armed guards, while those of Class II would be not on chains but under armed guards.

FIRST METHOD OF ORGANIZATION

The convicts in the first method of organization representing Class I or "honor men" would be divided into three groups, if the camp is of sufficient size, according to the work that the men are capable of doing. In the first group would be the most efficient men of the camp of whom would be expected a certain definite amount of work. The rest of the convicts of the camp would be graded into second and third groups. Knowing then what each group of men is capable of doing on an average as a day's work, the foreman of the road work could estimate what each group should easily be able to do in a certain time; and then, if the group were able by especially energetic work to accomplish more than the required amount, the men of that group should be allowed as a bonus a certain percentage of the value of the extra work that the group accomplishes, this to be paid in money and divided equally amongst them. The first group should be allowed 50 per cent; the second group, 40 per cent; and the third group, 30 per cent of the values of the extra work. The men should be permitted to spend this money at any time for things they wish that, of course, are not under the ban of the authorities.

As I have already stated, I believe that the convicts should be allowed a certain per cent of the value of the time that they are obliged to work for the State, the money thus earned to become accumulative and to be turned over to them at the expiration of their sentence; or to be turned over, if requested by the convict, at stated intervals to his family, provided that at all times there shall be a certain percentage of that earned by the convict to his credit in the Penitentiary Treasury. These two opportunities of actually earning money will be a very great incentive for the men to do better and more conscientious work and will also be an incentive for each man to see to it that each member of the group to which he is assigned does his part toward keeping up the record and reputation of the group. The amount allowed to convicts for their labor will vary according to the Class to which the convict is assigned. Those of the First Class should

receive a greater amount per day than that received by either of the other two classes; but each group of Class I should receive the same percentage. This would be a fair proposition inasmuch as the cost to the State of the men in the First Class is considerably less than those in the other two classes inasmuch as no guards are required and the men are on their honor. My idea is that no matter what the rate allowed per man be, the man of the First Class should receive one-third again as much as those in Class II; he, in turn, should receive one-third again as much as those in Class III. It will cause the men of the First Class to do their best to remain there, as they are able to earn more money; and it will be an incentive for the men of the third group to try to get into the second group, and for the men of the second group to get into the first group.

Those men of the First Class should also be receiving a commutation of their time. This varies in the different states, amounting to as much as ten days in one month in some states. If any man in Class I does not live up to what is expected of the "honor men" and breaks the rules and regulations of the camp, he may be reduced to a lower group; or, if his offense is very great, he may be reduced to Class II, and in the latter case he would lose what time has been commuted. If he attempts to escape he is to be reduced at once to Class III and will lose not only the time commuted but what money has been credited to him. Thus it will be seen that there is every incentive for the men in Class I to remain in that class; and I believe the men of that class will try and do their part to see that each one of the class lives up to what is expected of them. Those in Class II and III will see the great benefits that come to those in Class I, and will begin to do what they can to be transferred to Class I.

The accumulation of money that the convict has earned and the accumulation of time commuted from his sentence, which he knows will be lost if he attempts to escape or if he constantly breaks the rules and regulations of the camp, will be one of the strong motives that will prevent him from trying to escape; and, as will be seen later, this will also apply to the men of the Second and Third Classes. To my mind, however, one of

the strongest motives that will keep the men in Class I is the fact that confidence has been placed in them and they are trusted. It might be well at this point to state that any community that undertakes the working of convicts along the lines I am outlining must make it a point that *"honor men" must be "honor men" in every sense of the word.* There must be no guards of any sort. They must be housed, treated, worked, and fed similarly as in a military camp or perhaps in a railroad construction camp; differing from the latter, however, inasmuch as there would have to be certain rules and regulations similar to a military camp that the men must live up to; such as, retiring and getting up at certain specific times, being regular at meals, and other regulations that would be laid down by the Warden or Superintendent of the convicts. It is in this way that the convict realizes to the fullest extent the confidence that the State is placing in him and is believing that he will respect this confidence and pay his just debt by serving out his sentence.

SECOND METHOD OF ORGANIZATION

In this second method of organization where it is necessary to have the convicts guarded, the organization is somewhat different than in the first. In the first place we have two classes of convicts, one of which (Class III) are the men that have shown for the time being at best that they cannot be trusted in any way and have to be worked in stripes under armed guards and have to be chained at night.

Class II also has to be worked under guards, but it will be found that in some instances, as will be noted later, it will not be necessary that these guards carry exposed firearms. The men of Class II can be divided into two groups. Those of Group 1 would be considered men who are on probation before being transferred to Class I; and, while they are still worked under guards, it will not be necessary for these guards to carry exposed firearms. Group 2 would be worked under guards carrying exposed firearms but without chains. At night all the men of Class II would be in camp under armed guards. Those of group 1 would not be on a chain while those of group 2 would be. These men of Class II would wear some distinctive uni-

form, but not stripes. The men of Class II should be allowed a certain percentage in money of the value of their labor which, however, would be one-third less than that received by the men of Class I, and there would be no bonuses allowed for any extra work. The men in Group 1 of Class II would have the advantages over group 2 of not being under guards with exposed firearms, not being on the chain at night and being in direct line for transfer to Class I. This, I believe, would be incentive enough to keep these men from breaking the rules and regulations of the camp. Group 2 of Class II would know that by good behavior and good work they would be able to get transferred to Group 1 of the same class and in the end to Class I.

For infringements of the rules and regulations and for any attempt to escape, they would be punished similarly as stated for the men of Class I.

The men of Class III would be divided into two groups. Group 1 would be worked on the public roads but under guards and if necessary with chains. At night they would be under strict armed guards and on the chain. Those of Group 2 would be men whom it is not considered advisable to work on the public roads, and would be worked in stockades under armed guards and, if necessary with ball and chain. Those men could break rock for macadam, make cement drain tile, or other work that could be done in a stockade. With good behavior the men in Class III would be transferred from Group 2 to Group 1, and then from Group 1 to Class II, and so on to Class I. They would also be allowed for good behavior a commutation of their time and a certain per cent of the value of their labor in money. This, however, would be considerably less than that received by the men in Class II.

The one idea embodied in the above suggestions is that the rules and regulations of the camp and penitentiary authorities must be obeyed, but in obeying these the convict becomes entitled to and receives special consideration by the State.

The commutation of time would be the same for all classes of convicts provided, of course, that they are living up to the rules and regulations of the camp to which they are assigned.

The organization of the men who are to handle the convicts is of two-fold character: First, the men who take charge of the physical body of the convict; and Second, those who have charge of the labor of the convict.

The superintendent of the camp should have charge of the feeding, clothing, and guarding, when necessary, of the convict. He shall also be responsible for sanitary conditions of the camp and for the care of the sick. He shall provide the guards, when necessary, but these in no case should be permitted to act as foremen of the road work.

The superintendent of the construction work will have charge of the labor of the convicts, and he shall through his foreman direct such labor, and it shall be performed as he wishes it. He and the Engineer of road work of the State shall decide the amount of work that should be required of the convicts and determine what men shall be in the three groups of Class I. The division of the men into classes shall rest with the penitentiary authorities, but the superintendent of the work who comes in close contact with the convict may from time to time recommend changes, and shall report the refusal of any men to work as directed, which would constitute an infringement of the regulations of the camp.

It would not be necessary to work all the "honor men" of Class I in one camp, but certain numbers of these can be transferred to other camps where they would have special sleeping quarters, and would do such work as blacksmithing, bridge and culvert work, and other work where only one to three men are required and where it would be very expensive to provide a special guard for such a small number.

The question comes up and is often asked: Can long-term men be put on their honor and, as in the suggested organization, be placed in Class I; Can they resist the temptation to escape? I believe many long-term convicts can be worked as "honor men" and in Class I of the suggested organization. I believe that with a large percentage of them there would be less yielding to the temptation to escape if they were in Class I than if they were in Class II or III under armed guards.

These questions, however, of classification are settled by the

warden or superintendent, and they can usually determine pretty accurately who should be trusted. As I have already stated, except in extreme cases, I believe men sentenced for the first time can be started in Class I (with perhaps the exception of the negro convict). By personal contact, the prison and jail wardens come to know the prisoner and to know something of his character. I believe another good plan is for the superintendent and warden to get in touch with the prisoner's kinsfolk and get them in sympathy with the work of the prisoner and in having him serve out his sentence.

The prisoner's family should be encouraged to keep in touch with him, and should be permitted to visit him at stated intervals, and thus encourage him in every way to pay as rapidly as possible his debt to the State and encourage him in the feeling that there is a place for him when his sentence expires.

CONVICT CAMP

The convict camp will vary in its construction according as it is to be occupied by men of Class I or by men of Class II or Class III. If the camp is to be occupied entirely by men of Class I it can be established very similarly to a railroad construction camp. And there is no need of my going into any description for such a camp, except to state that it must be sanitary.

Wherever the camp is located and by whatever class of convicts it is occupied, it must be kept in a sanitary condition, supplied with pure water, and facilities provided for the men to bathe. All camps should be under the supervision or inspection of the State Board of Health.

Where camps are to be occupied by men of Class II, there are many plans that are in use for accommodating and taking care of the men. One camp I might describe used by State convicts in North Carolina, who are working a road in Henderson County, would be descriptive of one type of camp.

This camp, which is located near Bat Cave on the bank of Broad River, Henderson County, consists of a bunk house, or, as it is sometimes called, a "cell house" 30 x 60 feet, in the center of which is a double deck platform called the cell, upon

which are arranged the beds of the convicts. There is a clear space of 12 feet between each end of the building and double platform, and 6 or 8 feet clear between the cell and side walls. The space between the two platforms is approximately 5 feet. Each man is allowed a single mattress, so that he has plenty of room for sleeping purposes. Four chains run the length of the platform cell: one each side for the lower tier and one each side for the upper tier. To these chains the convict is fastened by a light weight ankle chain at night. This is so arranged that there is little or no weight on the ankle and he can turn in any position he wishes while sleeping. The construction of such a bunk house depends on the time of the year and length of time it is to be occupied; but it is always built so that there is plenty of air circulating through the building and that it may be kept warm and comfortable in cold weather. Guards are on duty in this building at night, one at each end.

Near to this building is the dining hall, kitchen, and store house. Surrounding these two buildings and enclosing an area of about one-fifth of an acre is a six-strand barbed wire fence. Just outside of this fence at opposite corners armed guards are stationed during the day. At night the only guards are within the bunk house. The sleeping houses for the superintendent, steward, and guards are a little distant from the enclosed area. The food supplied to the prisoners is the same quality as that supplied the guards and the steward. It is necessary that pure, wholesome food, clean and well-cooked should be furnished the prisoners, and that is what this camp tries to do.

In a camp of this sort, the men of Class II would have free run of the building and of the area within the fence during the daytime, but at night those of Group 2 would be fastened to the chain, while those of Group 1 would not. Cots could be substituted for the platform but in that case only one-half of the number could be accommodated, increasing the amount of floor space required and the number of guards.

Another type of camp is of tents with one platform along each side of the tent with a cleared space of about 10 feet between the two platforms. Where a camp is to be moved fre-

quently, the tents are very convenient as they are easily taken down, transported and set up again.

The bunk house or sleeping quarters of the Virginia convicts consists of a canvas tent or tent shaped building of sheet iron. Two rows of cots are placed in the center of the tent, and the men sleep with their feet toward the center. Along the line of cots is a long chain to which the convict is fastened by light weight chains.

As these road camps have to be moved at frequent intervals, it is economy to have them constructed in such a manner that they can readily be taken down, moved, and set up again.

Although the convict camps are to be under the supervision of the State Board of Health and certain definite rules regarding sanitation, cleanliness, etc., will be enforced; yet there should be a physician who would visit the camps every so often and examine the men to observe their physical condition. Where no such physician is employed by the State, for this purpose, arrangements should be made with a physician living in the vicinity of the camps to do this work. Every effort should be made to keep the men in good health and no pains should be spared to this end. The men, realizing that their health is being looked after by the State, will be more and more impressed with the idea that the State is trying to make men out of them, and will do more themselves to carry out the policy of the State in regard to its treatment of its convicts.

There should also be a Chaplain to look after the spiritual welfare of the convicts, and it is a good plan for the State to employ a regular Chaplain for this purpose. It will, of course, be impossible for one man to visit all the camps or convicts each week, but he could readily arrange with clergymen in the vicinity of the camps to hold religious services every Sunday. I do not believe in making attendance on these meetings compulsory, but am confident that a very large majority of the men would attend such Sunday services.

As stated above, the sanitary conditions of the camps of all the classes should be very carefully looked after, and the mattresses, bedding and clothing kept clean. But in addition to this the convict should be encouraged in every way possible to

keep himself neat and his individual part of the bunk house neat and trim. Chairs and benches should be provided around the bunk house.

Reading matter should be provided, and it will be found that a considerable proportion of the convicts will appreciate this very greatly. Donations of magazines can readily be obtained, to be sent regularly to the camps. Circulating libraries can, at little expense, be secured.

Colorado is a State that is using convicts of Class I in public road construction, but as yet is not using convicts that will correspond to Class II.

Virginia is working her convicts as Class II with the two groups. At nearly all the Virginia convict camps, there are a certain number of "trusties" that are trusted absolutely, representing Group 1, and the balance of the convicts represent Class II.

The difference in the cost of the work is all in favor of Colorado.

CHAPEL HILL, N. C.

THE CONDENSATION OF VANILLIN AND PIPERONAL WITH CERTAIN AROMATIC AMINES*

BY ALVIN S. WHEELER

In extension of the work done in this laboratory upon the condensation of chloral with aromatic amines,† we have carried out the condensation of the aldehydes, vanillin and piperonal, with *p*-aminobenzoic acid, its ethyl ester, and also with *p*-anisidine. Pawlewski‡ has described the product obtained by the condensation of anthranilic acid with vanillin, stating it to be an amorphous substance. We find that the para acid yields with vanillin a crystallin product with a melting point 40° higher. The condensation of anthranilic acid with piperonal was carried out by H. Wolf.§. Our product with the para acid melts 44° higher. The products with the ethyl ester have very much lower melting points. The work with the ester was undertaken with the hope of discovering more cases of isomerism, a few cases having already been observed in similar reactions. No indications of isomerism, however, were noted in handling the two ester derivatives.

The condensations take place readily in a boiling solvent with the loss of one molecule of water, one molecule of each constituent taking part in the reaction. By working at low temperatures it is sometimes possible to bring two molecules of the amine into combination with one of the aldehyde. In the reaction between the free para acid and piperonal a small quantity of a low melting substance, m. 171—3°, was isolated and the amount was greatly increased by using two molecules of the acid. Notwithstanding many analyses, no satisfactory figures could be obtained for a dibenzylidene derivative.

The condensation product of *p*-aminobenzoic acid with vanillin is unique among the benzylidene derivatives in that it is the only one that takes up a molecule of water of crystallization. Exposed to a moist atmosphere it gradually assumes a reddish

* Reprinted from the Journal of the American Chemical Society, Vol. XXXV. No. 8. August, 1913.

† Wheeler and Weller, This Journal, 24, 1063 (1902). Wheeler, *ibid.*, 30, 136 (1908). Wheeler and Jordan, *Ibid.*, 31, 937 (1909).

‡ *Ber.*, 37, 596 (1904).

§ *Monatsh.*, 31, 903.

color. If it is recrystallized from water, it becomes brilliant red. It is not a case of isomerism, for it loses one molecule of water at 100° and regains its yellow color.

EXPERIMENTAL PART

3-Methoxy-4-hydroxybenzal-p-aminobenzoic Acid, $CH_3O.$-$OH.C_6H_3CH:NC_6H_4CO_2H$, is prepared by boiling 1.37 grams (one mol) *p*-aminobenzoic acid and 1.52 grams (one mol) vanillin in 100 cc. toluene with the addition of 5 cc. alcohol. A little alcohol greatly diminishes the amount of toluene required. After boiling five hours under a reflux condenser, the solution is allowed to cool, the condensation product crystallizing out abundantly. A second crop of crystals from the mother liquor increased the yield to a total of 2.6 grams or 96% of the theoretical. The crude product, which melts at 204-6° was recrystallized from 200 cc. of toluene. The pure substance is deep yellow, consists of thin plates and melts at 211—2°.

Calculated for $C_{15}H_{13}O_4N$: C, 66.42; H, 4.80; N, 5.15
Found: C, 66.44; H, 5.12; N, 5.69

It was noticed that the rich, yellow crystals were often mixed with red ones. The first thought was that an isomeric compound was present, since some cases among analogous compounds are known, as the *o*-hydroxybenzalanthranilic acid described by Wolf. The whole mass turned red however in water and upon recrystallizing from boiling water a brilliant red substance, m. 104—6°, was obtained. After complete drying in the air, the product was heated to constant weight at 100°.

1.7860 g. lost at 100° 0.1150 g. H_2O.

Calculated for $C_{15}H_{13}O_4N.H_2O$: H_2O, 6.22; found: H_2O, 6.44.

3-Methoxy-4-hydroxybenzalethyl-p-aminobenzoate, $CH_3O.$-$OH.C_6H_3CH:NC_6H_4CO_2C_2H_5$, is prepared by boiling 1 gram-molecule of ethyl-*p*-aminobenzoate with 1 gram-molecule vanillin in 10 cc. benzene for six hours under a reflux condenser. The solvent was then evaporated off and the residue recrystallized three times from alcohol. The crystals, which are thin yellow plates, melt at 145° (cor.).

Calculated for $C_{17}H_{17}O_4N$: C, 68.18; H, 5.73
Found: C, 68.53; H, 5.79

3-Methoxy-4-hydroxybenzal-p-anisidine, $CH_3O.OH.C_6H_3CH$:-$NC_6H_4.OCH_3$, is prepared by boiling 1 gram-molecule of *p*-anisidine with 1 gram-molecule vanillin in 10 cc. benzene for six hours. Then after evaporation of the solvent, the product is recrystallized from ligroin. The pale yellow crystals deposit in radiating clusters, are easily soluble in most organic solvents and melt at 133.5° (cor.).

Calculated for $C_{15}H_{15}O_3N$: C, 70.00; H, 5.88
Found: C, 69.96; H, 6.09

3,4-Methyleneoxybenzal-p-aminobenzoic Acid, $CH_2 : O_2$:-$C_6H_3CH : NC_6H_4CO_2H$, is prepared by boiling 1.50 gram (one mol) piperonal and 1.37 grams (one mol) *p*-aminobenzoic acid in 100 cc. toluene for nine hours under a reflux condenser. The time was increased in this case to reduce the amount of a by-product melting at 171—3°. The chief product, which crystallized out on cooling, consisted of pale yellow prisms and could be recrystallized from toluene or water. The pure substance melts at 233—4°.

Calculated for $C_{15}H_{11}O_4N$: C, 66.90; H, 4.08
Found: C, 67.14; H, 4.64

If in the preparation of this compound the boiling was interrupted after two or three hours, a small amount of a substance melting at 171—3° could be readily islated. The amount could be greatly increased by employing two molecules of the acid for one of the aldehyde, but no satisfactory analytical figures could be obtained for a product containing two acid residues, in spite of many analyses.

3,4-Methyleneoxybenzalethyl-p-aminobenzoate, $CH_2 : O_2$:-$C_6H_3CH:NC_6H_4CO_2C_2H_5$, is prepared by boiling 1.50 grams piperonal and 1.65 grams ethyl-*p*-aminobenzoate in 10 cc. benzene for six hours. The product crystallizes poorly from benzene so the latter is evaporated off. Out of ligroin the compound crystallizes readily in long, pale yellow, glistening needles which melt at 109° (cor.).

Calculated for $C_{15}H_{15}O_3N$: C, 68.66; H, 5.08
Found: C, 68.96; H, 5.04

3,4-Methyleneoxybenzal-p-anisidine, $CH_2 : O_2 : C_6H_3CH :$-$NC_6H_4OCH_3$. The condensation of piperonal with *p*-anisidine is carried out exactly as that of vanillin with *p*-anisidine. The product crystallizes well from ligroin or benzene. The crystals are very pale yellow needles, which separate in feathery groups. Melting point, 117.5° (cor.).

The experimental work here described was carried out by Mr. L. E. Stacy, Jr., and Mr. L. B. Rhodes and I wish to thank them for their careful work.

CHAPEL HILL, N. C.

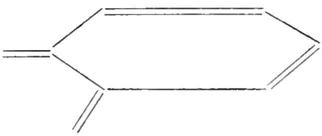
COLOR AND STRUCTURE IN ORGANIC COMPOUNDS*

BY W. L. JEFFRIES

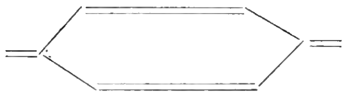
The very large number of organic compounds which are colored and the important place the dye stuffs occupy in modern industry have naturally caused chemists to seek some explanation of the color in compounds and just what relation the color bears to the structure.

In 1876 O. N. Witt offered the theory that color in organic compounds is due to the presence of certain unsaturated groups which are termed chromophores. The most important of these groups are the following:

C=C, C=O, C=S, C=N, N=N, N=O, $\mathrm{N}\begin{smallmatrix}/\!\!/\mathrm{O}\\ \backslash\!\!\backslash\mathrm{O}\end{smallmatrix}$. The ortho- and para-quinoid radicals,



ortho-quinoid



para-quinoid

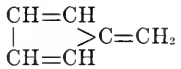
which may be regarded as a compact arrangement of the C=C group, were later added to the list.

A carbon complex containing such a group or chromophore is termed a chromogen. The chromogen may or may not be colored. If colorless it is necessary to introduce some salt-forming group such as NH_2 or OH. A group of this character is termed an auxochrome. For example, benzophenone, $C_6H_5.CO.C_6H_5$, although colorless is a chromogen since it contains the C=O group. On the introduction of the auxochrome, NH_2, to form aminobenzophenone, the compound becomes yellow. Similarly the nitro group is the chromophore of the chromogen nitrobenzene which forms the coloring matter of nitraniline.

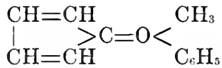
Color, depending on the chromophore, is intensified by its

* A report read at the January meeting of the N. C. Section of the American Chemical Society.

reduplication. For example hydrocarbons of the ethylene series, diphenyl- and tetraphenylethylene are colorless but diphenylhexatriene, $C_6H_5.CH:CH.CH:CH.CH:CH.C_6H_5$, is yellow. Absorption of color in the visible spectrum and the production of color seems to be promoted by the compact arrangement of double linkages in the ring structure. An example of this is the series of colored hydrocarbons discovered by Thiele and known as fulvenes.

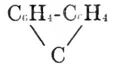


Fulvene—yellow liquid



Methylphenylfulvene—orange liquid

Being isomeric with fulvene and containing the same number of double linkages, it might be expected that benzene would be colored. That it is not may be accounted for by the difference of the grouping of the double bonds which cause the absorption bands to shift within the ultra violet region of the spectrum. It seems certain that the $\begin{matrix}=C\\ =C\end{matrix}\!> C =$ group is an important factor in color production. The influence of ring structure in deepening color is shown in flourenone,



which is red while benzophenone is colorless. Reduction or replacement by chlorine and sometimes hydration of the CO group destroys color.

Although the color effect of the C═O group is not apparent in the simple aldehydes or ketones or even in compounds where the C═O groups are separated such as acetylacetone, $CH_3.CO.-CH_2.CO.CH_3$, a continuity of these groups does produce color. To illustrate, diacetyl, $CH_3.CO.CO.CH_3$, is yellow and the anhydrous triketone $CH_3.CO.CO.CO.CH_3$, is orange. The color appears to deepen with the increase in the number of C═O groups.

The C:S group appears to have greater effect as a chromophore than the C:O group as instanced by comparing tetramethyldiaminothiobenzophenone, $CS[C_6H_4N(CH_3)_2]_2$, which is yellow while the corresponding ketone is colorless.

The chromophore effect of the N=N group is illustrated in the numerous azo dyes. It is peculiar to note that in the case of the azo group, ring structure seems to diminish rather than to intensify color. The blue or green effect which most of the nitroso compounds exhibit may be attributed to the N=O group. The absence of color in certain compounds containing this chromophore may be explained by the bimolecular structure and consequent saturation of valencies.

From a study of compounds containing the chromophores it seems that they may be divided into two classes, those such as N=N and N=O which produce color independent of the nature of their environment and are therefore called independent chromophores, and those such as C=O and HC=CH which act only in conjunction with other groups and hence are called dependent chromophores.

That a slight difference may have a marked effect on the color of a compound is shown by certain stereoisomers such as the two dibenzoyl ethylenes, $C_6H_5.CO.CH:CH.CO.C_6H_5$, one of which is colorless and the other yellow.

As has been stated above, a compound containing a chromophore may not be colored and the introduction of an auxochrome may be necessary to produce color. The introduction of an auxochrome into a compound already colored serves to intensify the color. Of the two chief auxochromes, OH and NH_2, the latter seems the stronger as shown by a comparison of para-nitrophenol and para-nitraniline. It is worthy of note that both groups possess residual affinity and like the chromophores are highly reactive. It has been suggested that there may be an interaction of the two kinds of groups to produce a banded spectrum when light is absorbed.

The color of a compound is deepened or intensified by the replacement of hydrogen in the NH_2 by alkyl or aryl radicals, and as the molecular weight of the radical is increased the absorption is shifted towards the red. If the hydrogen of the OH group is replaced by a radical, it may either intensify or diminish color. It might be expected that the relative position of the auxochrome to the chromophore would have marked effect on the color. But the fact is that the closeness of the auxo-

chrome to the chromophore as frequently destroys color as intensifies it but Kauffmann concludes that when the auxochrome is attached indirectly to the chromophore by an aromatic nucleus which can function as a chromophore, the color is intensified.

Kauffmann, in a variation of the foregoing, offers what is sometimes called the auxochrome theory. He considers that those substances which at atmospheric pressure have the property of luminescence possess certain characteristics in common which form the basis of color. Luminescent compounds are mainly benzene derivatives and contain certain groups which Kauffmann terms luminophores. Benzene is regarded as the seat of luminescence. Benzene itself is only feebly luminescent but the effect may be intensified by the introduction of an auxochrome, by the multiplication of aromatic nuclei, or by linking nuclei with unsaturated carbon chains. Benzene is optically colored for it produces in the ultraviolet a banded spectrum. The effect produced by the introduction of auxochromes is to shift the absorption toward the red and thus produce color. Some of the absorption bands of nitrobenzene lie just within the visible spectrum so a weak auxochrome produces visible color.

Hantzsch has advanced a theory of color in compounds which has become known as the theory of chromoisomerism. His theory has been developed principally from observations concerning the nitrophenols in which the chromophore, NO_2, is alone too weak to produce color until reinforced by the auxochrome, OH, the chromogenic character of which is intensified by conversion into the salt. Hantzsch holds that all true nitrophenols and their derivatives are colorless. For instance dinitroethane $CH_3CH(NO_2)_2$, is colorless but on the formation of the sodium salt, which is deep yellow, there is a change in the form to $CH_3C(NO_2)NO.ONa$ called the *aci*—form corresponding to the pseudo acid and acid forms of phenylnitromethane. He expresses his general idea thus: "Every appearance of color or change of color in salt formation with a colorless metallic ion is due to isomeric change." The process of isomeric change he terms chromotropism. The attempt to extend the theory by further experimental observation has only

rendered the issues more complex and the explanations more involved.

Hartley offers a theory in explanation of color which is markedly different from any of those discussed above. In a discussion of his theory he says, " color may be visible or invisible, but a visible color is one which causes absorption of any rays with wave lengths not less than 3933, the more refrangible rays in the violet H_1 and H_2, and not greater than 7951, the deep red rays of rubidium."

As stated earlier benzene shows a series of narrow absorption bands in the ultra-violet and these bands become displaced towards the visible region of the spectrum by the introduction of certain groups. Hartley contends that when two or more benzene nuclei are fused or an auxochrome such as OH or NH_2 is introduced into the nuclei there is a displacement of the bands towards the visible region of the spectrum. Hartley's theory is that the fusion of the nuclei or the introduction of an auxochrome brings about a retardation of the period of molecular vibration or damping of their oscillation; that is the absorption bands are shifted towards the red. A chromogen is regarded as an invisibly colored substance and a chromophore as an atom or group which reduces the speed of vibration so that there is an absorption of rays within the region of visibility. While the linking of benzene nuclei may not produce color, it does reduce vibration and bring therefore the absorption bands nearer color. For example, triphenylmethane, though colorless or pale yellow when fused, produces a broad band of the same general character as benzene but of greater intensity and much nearer the margin of the visible spectrum. It is therefore a chromogen. Para-nitrophenol absorbs faintly in the violet and possesses a green tint though apparently colorless. When it is converted into its sodium salt, the absorption shifts towards the visible spectrum. There is not, as Hantzsch's theory would require, any change of structure. Formanek has studied a large number of dye stuffs and the relation of color to structure in them. He concludes that coloring matters which have analogous structure possess similar absorption spectra and the same is true of those which have the same chromogen and the same number of

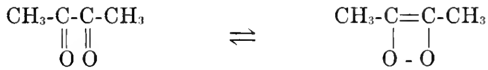
auxochromes, $C_6H_5NR_2$ or C_6H_4OH groups. If the chromophore is different or if, with the same chromophore the number of $C_6H_5NR_2$ groups vary, or if the position of the auxochrome varies in its relation to the fundamental element, the absorption curve is different.

Hartley states as a rule, "all open chain hydrocarbons exert a continuous absorption, the extent of which is dependent upon the number of atoms in the molecule." Hydrogen is the most colorless substance known, which fact Hartley explains by saying that the rate of vibration of its atom or its molecule is the most rapid of all elements. This may be attributed to the fact that its mass it much less than that of any other element—perhaps its rapid vibration may be due to the large amount of energy associated with the molecule. That hydrocarbons are the least colored of all carbon compounds is due to the energy of the hydrogen atoms being communicated to the whole molecule. This may account for hydrogenized matters becoming colorless. The greater the proportion of hydrogen the faster the vibration. Naturally the introduction of a heavier atom or group in place of the hydrogen will lower the rate of vibration and bring the absorption nearer the visible spectrum; sufficient damping will produce color.

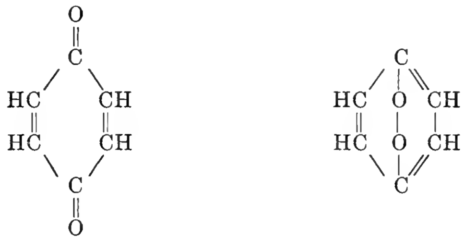
Armstrong has advanced the theory that the production of color is dependent upon special modes of atomic arrangement, and particularly on such modes as involve the existence of a condition of strain in the resulting system due probably to the peculiarities in the affinity relationships of the different constituent elements of the system which prevent mutual neutralitation of the affinities. The occurrence of color would then more frequently than not be concomitant with a high degree of reactivity, the colored compound being one of high potential or slight stability. The dominant feature of the arrangement is a comparison of the unsaturated hydrocarbons with the paraffins. The paraffins, which are singularly inert and all but colorless, contain carbon atoms united by single bonds. The unsaturated hydrocarbons begin to manifest color in the regions above and below the visible spectrum. These compounds are

represented by formula in which the carbon atoms are united by double or triple bonds.

Wm. J. Hale explains color as being due in both aromatic and aliphatic compounds to the oscillations of the bonds within the molecule and this he calls isorropesis. His theory is that a change in linkage produces the absorption bands. This he illustrates by diacetyl in which the make and break may be shown thus:



The make and break contact between the oxygen atoms would give marked activity to these atoms. The color in quinoid compounds is due to isorrepsis in this manner:



Isorropesis occurs between adjacent carbon atoms possessing residual affinity and the para carbon atoms are considered as possessing the relationship as indicated by their chemical behavior which is as if the atoms lay next each other. Isorropesis need not always occur between oxygen atoms possessing residual affinity but other atoms may show similar reactions. For example the nitranilines, $H_2N\text{-}C_6H_4\text{-}NO_2$, given an absorption curve similar to that of para-benzoquinone. Here the residual affinities of the N atoms are disturbed by the motion of the benzene molecule. In compounds of the benzene structure, the cause of the color begins with the vibration of the molecule itself.

The presence of other groups may augment or retard the influence of unsaturated atoms undergoing isorropesis and consequently the corresponding variations in the oscillation frequency will be indicated by similar variation in the nature of

the color. Hale concludes that isorropesis is the cause of color in the aromatic as well as the aliphatic series. In both series he considers the two modifications that must always be "in statu nascendi" to have actually been shown to exist. "The change of linking therefore, that must accompany the transformation of one into the other is certainly to be considered as the source of the oscillations which give rise to the vibrations in the ether of a free period corresponding to those in the visible region of the spectrum and hence the development of color in the substance."

The foregoing is in brief the most important of the theories advanced in regard to color and its relation to structure. As indicated by the great difference in the essential as well as in the minor details of the theories, the subject is far from closed. The field is intensely interesting and promises important developments.

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CHAPEL HILL, N. C.

TIMBER RESOURCES OF ORANGE COUNTY, N. C.*

BY J. S. HOLMES

Orange, with an area of 247,040 acres, is one of the middle eastern Piedmont counties. It lies between Durham on the east and Alamance on the west, both of which were originally part of this county.

Lying on the eastern edge of the granite formation and on the western border of the old "Triassic Sea," the topography of Orange is rougher and more broken than most of the other counties in this part of the State. Several low rocky ridges run part way across the county in an easterly and westerly direction, and close to Hillsboro are some hills, which rise several hundred feet above the town. The northeastern part of the county is drained principally by Eno and Little rivers, which uniting in Durham County with Flat River, form the head of the Neuse. The western part is drained by several creeks which flow southwesterly into Haw River, which when augmented by the waters of New Hope Creek, which drains the southeasterly part of the county, becomes the Cape Fear River. The streams are too small to form water powers of any size, though two or three small saw and grist mills are run by water power.

The soil varies from sandy and gravelly to a stiff red clay. An area of sandy loam varying in width from two to five miles crosses the northern part of the county. On this land tobacco is being grown in increasing quantities. A small area of sandy land also occurs near the southwestern corner of the county. Except along the southeastern border, where much of the soil is a yellowish gravelly clay, most of the rest of the county has a heavy red clay soil. Cotton and the cereals are the chief crops.

Approximately 40 per cent of the land area is now cleared. Of this cleared land nearly one-fifth is neglected and unused, and is gradually reverting to forest growth. There are no large timber tracts, and only seven per cent of the land is held by parties who own over 500 acres. An average assessed value for

* Reprinted from Press Bulletin No. 116 of the N. C. Geol. and Econ. Survey.

land is from $5 to $6 per acre. Its sale value runs from $10 to $20 per acre, and in the tobacco growing section considerably higher.

The North Carolina division of the Southern Railway runs through the county from east to west, while a ten-mile branch runs south to connect Chapel Hill with the main line. The wagon roads are at present very inadequate, though with the money secured by the recent issuance of bonds, a system of graded and surfaced main roads is now being constructed. There is, at present, little attempt, either amongst the population or on the part of the county authorities, to keep up the small crossroads; and these are in a serious condition. At present Orange County's best markets are at Mebane and Graham to the west and at Durham to the east. There is, as yet, no cash market at Hillsboro. Outside of the cotton mills at Hillsboro and Carrboro, little manufacturing is done. A factory at Efland makes excelsior from pine wood; while one or two small firms manufacture hickory handles and shuttle blocks. An attempt is also being made to produce cedar oil from the sawdust and twigs of the cedar.

The forests of Orange, which occupy 58 per cent of the county, are divided almost equally between hardwood and the old field pine types. It is estimated that these forests support an average stand of 620 feet of timber per acre, or a total stand of nearly 90,000,000 feet. Of this amount approximately 51 per cent is second-growth pine; 46 per cent oak; one per cent cedar; about one-half per cent each of poplar and "forest" pine; and the balance chiefly hickory. There is also thought to be as much as 3,000 cords of merchantable dogwood in the county.

The hardwood forests occupy the rougher and poorer areas, such as the hills, ridges, and broken country in the middle and southern parts of the county. There are also considerable areas of what are commonly called post oak flats. Most of the hardwood forest has been cut-over, some of it very closely, but here and there are found small tracts of merchantable oak, running from 2,000 to 5,000 feet to the acre, or even more. White oak and post oak are the principal merchantable trees, forming 80

per cent of the hardwood stand. The greater part of the oak timber is best adapted for the production of cross-ties; and this is the use to which it is being largely put. The red oaks, chiefly Spanish, black and scarlet oaks, form perhaps 15 per cent of the stand, while most of the remainder is hickory. There is very little poplar in Orange County, and less sweet gum. Though cedar occurs mostly in the old field pine type, some good merchantable cedar is found on some of the hardwood areas. It is said that no pine was originally mixed with the hardwoods in this county south of the sandy areas in north Orange. There is now, however, some merchantable pine in many hardwood areas, and pine seedlings and saplings are found coming in over perhaps the greater part of the hardwood forest.

The old field pine type occupies land which had at one time been cleared for agriculture, but which was subsequently abandoned. As a rule, therefore, it is more level and better adapted to farming than the hardwood land. It is estimated that about 15 per cent of this type contains merchantable timber, with an average stand of about 4,000 feet per acre. Practically all of this timber is second-growth pine, though many areas contain a percentage of cedar. Probably 60 per cent. of the pine forests are pole stands, the trees being below merchantable size.

Three species of pine occur in commercial quantities in Orange County. Shortleaf forms from 50 to 100 per cent of the pine stand throughout the county and in all but three townships—Chapel Hill, Eno, and Hillsboro—more than 95 per cent of it. In these three townships, constituting the southeastern third of the county, loblolly pine occurs plentifully; in the former township, between 30 and 40 per cent of the pine being of this species, while in the two latter about 15 per cent is loblolly. In the southern part of Bingham Township also about 10 per cent of the pine is of this species. The proportion of loblolly pine in the young growth is usually greater than it is in the merchantable timber, showing that this species is gaining ground in Orange. Scrub or "spruce" pine only occurs in any quantity in the northwestern quarter of the county where in two townships it forms about 5 per cent of the pine stand.

A few isolated patches are found also in the other northern townships.

The stumpage value of timber varies according to the distance from the railroad. Pine is worth from $2 to $2.50 per thousand, while cedar brings about $5. Oak stumpage varies from $2 to $3.50 per thousand. Some sales of mixed pine and hardwood have been made at as low a price as $1 per thousand for both pine and oak.

Lumbering on a large scale has ceased in Orange County. Though the total cut last year exceeded eight and three-quarter million feet, not more than one-half dozen mills exceeded a cut of 500,000, and no mill cu't as much as a million feet. Fifty-four sawmills, of which thirty are small stationary mills cutting chiefly for local customers, operated last year. These cut approximately 4,000,000 feet of oak over one-half of which went into ties, 3,300,000 feet of old field pine, 1,000,000 feet of cedar, and 350,000 feet of "forest" pine. This makes an average annual cut of about 160,000 feet per mill.

For the past two years, and especially since the fall of 1912, when the failure of the crops made it necessary for the farmers to earn some extra money, the production of cross-ties has been an important industry. During 1913 it is estimated that at least 200,000 ties were cut and marketed, probably 75 per cent of them being hewn. This means a cut of about three ties per acre from all the hardwood land in the county and a money yield to the farmers exceeding their receipts for the cotton crop. Cross-ties delivered at the railroad have been selling at from 50 to 55 cents each for first class ties and 35 to 40 cents for second class ties.

It costs 10 cents per tie to have them sawn by a local mill, or 12½ cents each to get them hewed, while 2 cents per tie per mile will cover the cost of hauling. Stumpage prices range from 7½ cents to 10 cents per tie. It can be seen then that where the roads are good and the distances not too great, owners of tie timber can market it profitably at present prices. And they are certainly doing it.

Though landowners oppose burning the woods, yet through carelessnes or indifference a good many fires of greater or less

extent do occur nearly every year. As a rule, little timber is injured, though sometimes a good deal of cedar is killed. The chief damage, however, is to the young pine growth, which ought to be encouraged, not only in the pine type, but even more so in the hardwoods. In cutting timber, owners should endeavor to leave seed trees of pine, in order to increase the percentage of pine in the next crop. The spread of the loblolly pine should be assisted in every way possible, while, in the northeastern part of the county, the scrub pine should be cut in order to give the other species an opportunity to fill up the ground. At the present rate of cutting the old growth timber will soon be gone and the pine, because of its rapid growth, must be the main dependence for the future.

CHAPEL HILL, N. C.

WORK AT THE BEAUFORT LABORATORY

BY W. C. GEORGE

The work carried on annually at the Bureau of Fisheries laboratory at Beaufort, North Carolina, is of interest not only to scientific men generally but is of especial interest to biologists and others in North Carolina who are concerned in any way with the natural history of the State. And so it seems fitting to give in this place some account of the work carried on at the laboratory during the past season. There is no intention on the part of the writer to announce results or to encroach in any way upon the special reports on this work; but to give only such an account as might be given by a scientifically trained visitor of the laboratory.

The abundance and variety of the fauna and flora of the Beaufort region, together with the laboratory facilities provided by the Bureau of Fisheries, afford opportunity for a great diversity of biological work there, and every season there are a number of investigators at the Beaufort station carrying on varied and important researches. Only a brief reference will be made to the work of each of those who worked at the laboratory during the summer of 1913.

Professor S. O. Mast, of Johns Hopkins University, carried on an extensive investigation on the behavior of fishes with respect to conditions of light. It was already known that the background on which fishes lie greatly affects the arrangements of the pigment cells in the skin, and thus fish assume a very different appearance on one background from that which they have on another. For Dr. Mast's experiments the flounders proved very good subjects with which to work; and with some very ingeniously devised aquarium arrangements he has already reached interesting results and has learned something further in regard to the responses of animals to light.

Dr. W. P. Hay, Professor of Biology in the Washington City High School, was engaged in a study of the decapod crustacea of the region. Some years ago Dr. C. A. Shore, of Raleigh, collected during several summers the larger crustacea, particu-

larly crabs and shrimps, of Beaufort harbor; but through press of other work he was not able to complete his study of these forms. Dr. Hay is carrying on this investigation and will before long have an amply illustrated paper, which will enable any one to identify the crabs and shrimps of the region. These forms are of such general interest to fishermen and amateur collectors and naturalists that the paper will be extensively used by visitors to our coast.

Dr. J. J. Wolfe, Professor of Biology in Trinity College, was engaged in botanical work for the Bureau. Few people except naturalists are aware of the immense number of minute plants and animals that float at or near the surface of the sea. This flora and fauna, known as the plankton, constitute the food of most young fishes, and in every quarter of the world some effort is being made to determine just what forms are present, and to learn something about their movements and propagation. Dr. Wolfe is occupied in a study of the microscopic plants, especially the diatoms. Another investigator, Dr. Edmundson, of the University of Oregon, was engaged in a study of the microscopic fauna, the protozoa. These are groups which have practically never been studied along the South Atlantic coast and so their study should yield fruitful results.

Dr. H. V. Wilson, Professor of Zoology in the University of North Carolina, was engaged in a study of the Philippine sponges. Some years ago the Bureau of Fisheries undertook an extensive survey of the waters in the neighborhood of the Philippine Islands. Large collections of the various zoological groups were made, and the collections of these groups were handed out to numerous specialists to be reported on. The collection of sponges is very large and contains representatives of all the sub-divisions of the group. It was upon a study of these forms that Professor Wilson was engaged.

The work of Mr. L. F. Shackel, of the St. Louis School of Medicine, was with the ship-worms. Among the animals that are destructive of property along our coast none is more troublesome than the ship-worm. This is really not a worm at all but a bivalve mollusc. In very young stages they begin to burrow

into wood. They excavate wharf piles, boat timbers, etc., and do very great damage. Mr. Shackel is carrying on investigations which have for their object the determination or invention of new ways for preventing these animals from entering wood.

In addition to this more general biological work the Bureau is carrying on detailed work on the fishes. Considerable attention has already been paid to the fishes, but the group is so important that the most detailed knowledge of it is desirable. And so the director of the laboratory, Mr. Lewis Radcliffe, with the help of a number of assistants, is constantly making collections and observations on the group. A few years ago a book on the North Carolina fishes, by Dr. H. M. Smith, now chief of the Fisheries Bureau, was published by the North Carolina Survey. Mr. Radcliffe and others have been able to add a number of forms to those already recorded. And what is of even greater importance, they are learning more about the life histories of the Beaufort fishes. Dr. Albert Kunz, of the University of Iowa, studied the development of a number of the more abundant forms. This is a field not only of scientific but of great economic interest and importance. The eggs of these fish are very small and float at the surface of the water, and may be captured in fine meshed nets. With the aid of an accomplished artist, Mrs. Decker, of Washington, D. C., some very beautiful figures of the stages in the development of these forms have been made.

Mr. H. F. Taylor, of the Tarboro City Schools, was engaged in work on fish scales to discover if the age of fishes might be determined thereby.

Besides a general study of a number of forms, my own work was mostly in following the phenomena of reduction in the medusæ of Pennaria. Every evening just at dusk during the breeding season the mature medusæ of Pennaria come off from the colony. They swim about in the water for a time casting the eggs and sperm, and then they settle down to the bottom and begin to degenerate. In this process of reduction the medusæ pass through some interesting stages which it was my purpose to follow. The work has not yet been completed.

Aside from the more purely scientific work, the laboratory is engaged in breeding Diamond Back Terrapins, an enterprise of direct economic importance. The object of this work is the elaboration of methods for artificially rearing the Diamond Back Terrapin. The success of the work is already such that it is now possible to breed these terrapins for the market, and private parties in Beaufort have built breeding pens and have started the work on a commercial basis. The breeding experiments, which are under the supervision of Dr. W. P. Hay, are still being continued.

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THE REDUCTION OF NAPHTAZARINE

BY ALVIN S. WHEELER AND CHAS. S. VENABLE

The reduction of naphtazarine was first carried out by Zincke and Schmidt (Ann., 286,27 (1910)). The more descriptive name of this compound is, 1, 2-dihydroxy-5, 8-naphthoquinone, formerly called 5, 6-dihydroxy-1,4-napthoquinone. The authors mentioned employed stannous chloride and hydrochloric acid, stating that the reaction did not go to completion if zinc dust was used. The reddish brown quinone is converted into the dull yellow tetrahydroxynaphthalene, designated by them as 1,4,5, 6-tetraoxynaphthalene, now more properly described as the 1, 2, 5, 8-tetrahydroxynapthalene. This compound is a peculiarly interesting one on account of the ready change which it undergoes in solutions. In the solid state it consists of yellow needles which turn red as they melt at 154°. All solutions in organic solvents turn red on standing, and a product more or less red is recovered therefrom. When pure this substance also melts at 154°. According to Zincke and Schmidt it has the same composition as the yellow reduction product. In view of the ready oxidation of the yellow tetrahydroxnaphthalene to the reddish brown naptazarine, the authors came to the conclusion that the red product melting at 154° was in reality the yellow compound mixed with a small amount of oxidation products. They obtained the same acetyl derivative from the yellow and the red compounds. We are unable to concur in this view, knowing what a marked effect in lowering the melting point only slight quantities of impurities have. We propose another explanation which lies in the theory that we have here a case of desmotropy in which a labile hydrogen is causing a keto-enol isomerism.

$$(A)\quad \begin{array}{l} -C-OH \\ \;\;\| \\ -C-H \end{array} \quad \rightleftarrows \quad \begin{array}{l} -C{=}O \\ \;\;| \\ -C{=}H_2 \end{array} \quad (B)$$

A represents the enol form and B the keto form. The first type is a phenol or if in the aliphatic series an alcohol while the second type is a ketone. New cases of this sort have been coming to light in recent years. It is clearing up some doubtful questions of constitution. For instance Meyer (Ann., 379,37 (1910)) has lately shown that anthranol is in reality anthrone, the keto-form. As a rule when these isomeric forms are separate and in the dry state they are stable but in solution they are unstable and pass readily into each other. The reaction is reversible and incomplete. The direction of the reaction depends upon the temperature and the nature of the catalysor. Since both forms exist in the same solution, the solution will respond to the reaction of the hydroxyl group and of the carbonyl group. The relative amounts of the two forms in solution is difficult to determine, since the equilibrium is very readily disturbed. A number of methods have been employed. Meyer (Ann., 379,37 (1910), 396,141 (1912)) has proposed a titration method with bromine at a low temperature. The enol-form, e. g., anthranol, gives a strong blue fluorescent solution whereas the solution of anthrone is non-fluorescent. Since bromine acts quickly upon the enol-form and not upon the keto-form, the end point or disappearance of the fluorescence is readily seen if the solution is illuminated by ultraviolet light given by iron electrodes. This method we were unable to use in our case though we made a number of attempts to do so. We found that the action of bromine upon the tetrahydroxynaphthalene was not smooth and sufficiently well defined.

An alkaline solution of the yellow compound shows a strong greenish fluorescence, indicating the presence of at least some of the enol-form. The reaction with acetic anhydride, which yields a tetracetyl derivative, also points to the enol-form but Zincke and Schmidt give no indication of the yield obtained. Reactions in strongly alkaline solutions applicable to the carbonyl group can not be made owing to the ready oxidation to naphtazarine. For this reason we are employing phenylsemi-

carbazine which is weakly basic and propose to follow with semicarbazine which is not so weak a base. Conclusive statements can not yet be made as to the constitution of the yellow and red forms but the question is being actively studied in our laboratory.

EXPERIMENTAL PART

Purification of Naphtazarine

We were presented with one-half kilogram of naphtazarine by the Badische Anilin u. Soda Fabrik in Ludwigshafen am Rhein and wish to express here our sincere thanks for the same. In order to bring the material to a higher state of purity we tried to recrystallize it from various solvents but could find no suitable solvent. So we resorted to the sublimation process, employing a large sublimation apparatus similar to one described by Morey (Journ. Amer. Chem. Soc., 34,550 (1912)). The copper or platinum vessel containing the substance rested upon a resistance coil of nichrome wire carrying 1.5 amperes of current. This was placed upon a very tall inverted beaker which stood in a large flat crystallizing dish. Over the whole was inverted a bell jar and a still larger one over this. The whole rested upon a metallic plate, the bottom of an old vacuum pump with a hole in the center. This hole gave insertion to the tube leading to the May-Nelson electric vacuum pump. A vacuum of 2 to 10 mm. was maintained 5 to 8 hours for each 15 gram lot. One-third of the material was non-sublimable. The sublimed product consists of glistening green needles which upon being powdered formed a dark red mass. Naphtazarine possesses no melting point but sublimes above 140°.

Reduction of Naphtazarine

The naphtazarine was reduced by suspending 20 grams in 95 per cent. alcohol, adding 100 grams stannous chloride dissolved in 50 cc. concentrated hydrochloric acid and boiling the mixture on the water bath under a reflux condenser for thirty minutes. This produced a clear greenish red solution containing only a few insoluble particles. An odor of hydrogen sulfide was quite pronounced. In order to isolate the product it is very unsatisfactory merely to pour the solution into water or

dilute hydrochloric acid and filter. After many experiments we proceeeded as follows. The alcoholic solution is poured into 5000 cc. 12 per cent. hydrochloric acid and heated to boiling till practically all of the precipitated product has redissolved. Small insoluble impurities were filtered off on a Buchner funnel with suction while the solution was hot. On allowing the filtrate to stand over night, a mass of yellow needles had separated. These were filtered off, washed with water and dried. The yield was 9 grams. The product melted at 153°. The crystals are a dull yellow but powder to a bright yellow mass. The compound is easily soluble in alcohol and chloroform, fairly soluble in carbon tetrachloride and only slightly soluble in gasolene. The solutions turn red on standing even when air is displaced by nitrogen. Solutions in alkalies are blue with a brilliant fluorescence. The sodium or potassium salt which separates out however is that of naphtazarine. This oxidation we found will take place even at 0° and in an atmosphere of carbon dioxide. The tetrahydroxynaphthalene is therefore very sensitive to alkalies.

Preparation of Phenylsemicarbazine

Phenylsemicarbazine was prepared by first making phenylurea from aniline by the action of potassium cyanate and then treating this with hydrazine hydrate. In order to make the phenylurea the method of W. Weith (Ber., 9,820) was followed. One molecule (25g) aniline was mixed slowly with one molecule (25cc. sp. gr. 1.17) hydrochloric acid. The mass was cooled and one molecule (21.8g) of potassium cyanate was added slowly. The nearly solid mass was filtered, washed and dried on a porous plate. Yield, 26g. The melting point was 147°. The formula of phenylurea is $NH_2.CO.NHC_6H_5$. To convert the phenylurea into phenylsemicarbazine the method of Curtius and Burkhardt (Journ. f. prakt. Chem., (2) 58,220) was followed. Ten grams of phenylurea were placed in a small round bottom flask with 5g absolute alcohol and 8g hydrazine hydrate. The flask was attached to a reflux condenser with a ground glass joint and the mixture was boiled fifteen hours. On cooling the mass solidified. This was rinsed out into a porcelain

dish with water and heated upon a water bath until the odor of ammonia could no longer be detected. The product was impure and remained so after extraction with ether. It was therefore converted into its hydrochloride by adding 5 parts of alcohol and 5 parts of concentrated hydrochloric acid. The resulting emulsion was filtered with suction and washed with very little water. The residue was dissolved in 5 parts of water, filtered from slight impurities and finally neutralized with pure sodium hydroxide. The resulting solution was allowed to crystallize slowly. The product obtained thus was pure, melting at 122°. This is a very efficient addition to the purification process of Curtius and Burkhardt. The formula is $NH_2NH.CO.NHC_6H_5$. The melting point of the hydrochloride is 216°.

Action of Phenylsemicarbazine on Tetrahydroxynaphthalene

The action of phenylsemicarbazine on the yellow and the red forms of tetrahydroxynaphthalene was studied simultaneously. The amounts used were in the proportion of one molecule to one molecule. Saturated solutions of each were mixed and two series were carried out, one in alcohol solution, the other in chloroform solution. The solutions were kept in beakers placed in desiccators. In the alcoholic solutions precipitation began about the fourth day and gradually increased, a slow evaporation of the solvent taking place simultaneously. The precipitates were dark colored, the solutions being dark red. Recrystallized from alcohol the products became lighter brown and behaved similarly on heating in a capillary tube, darkening at 205° and decomposing at 214°.

In the chloroform series the yellow form made a yellow solution and the red form a red solution. On the third day the precipitation began in the yellow solution but none took place in the red solution until the seventh day. Precipitation continued in each case until the weight of the precipitate was equal to 55 per cent. of the total weight of the reacting substances. The crystals in both cases were light yellow in color and behaved upon heating like the products from the alcoholic solutions. The analytical work was interrupted before entirely satisfactory

figures were obtained for a pure phenylsemicarbazone, although a good figure was obtained for carbon. The hydrogen persisted in being 0.6 to 0.8 per cent too high. It is not surprising that phenylsemicarbazine should cause a reaction in solutions of both the yellow and the red forms since in solution both enol and keto-forms exist simultaneously. A further study of this question is under way.

Bromination of Tetrahydroxynaphthalene

According to Meyer enol forms react instantaneously with bromine whereas saturated keto-forms do not. The constitution of tetrahydroxynaphthalenecomplicates this reaction because the bromine may not only act upon the four hydroxyl groups present but also upon the four hydrogen atoms in the nuclei. We made four comparative experiments using 1, 2, 3 and 4 molecules of bromine respectively for one molecule of the tetrahydroxynahthalene. Saturated glacial acetic acid solutions of both substances were used and the reactions were started at 10°. No reaction was apparent at first in any case but on standing at room temperature over night masses of crystals appeared in every case. The results are briefly stated as follows: I. 0. 5g substance + 0.47g Br. Product, black crystalline mass, 0.46g. Sublimes at 260° without melting. II. 0.5g substance + 0.94g Br. Product, red crystals, 0.63g. Sublimes at 160-200°. III. 0.5g substance + 1.41g Br. Product, reddish orange crystals, 0.78g. Sublimes at 150-240°. Melts at 240-252°. IV. 0.5g substance + 1.88g Br. Product, yellowish orange crystals, 0.56g. Melt at 168-174° and decompose above 174° to a dark red liquid. The last product appears to be the purest but there is a decided falling off in the yield. The reaction will be studied further in this laboratory.

CHAPEL HILL, N. C.

CONVOCATION WEEK MEETINGS OF THE SCIENTIFIC SOCIETIES

THE AMERICAN ASSOCIATION

For the first time since the New Orleans meeting in 1906 the American Association for the Advancement of Science came south during the Christmas holidays for its regular winter meeting—from December 29, 1913, to January 3, 1914. Atlanta was the city chosen, and it lived up to its reputation by giving the scientists a cordial and hospitable welcome. The affiliated societies that followed the Association this year (somewhat fewer than usual, as was to be expected) were the following:

Astronomical and Astrophysical Society of America.
Botanical Society of America.
American Association of Economic Entomologists.
Entomological Society of America.
American Microscopical Society.
American Physical Society.
American Phytopathological Association.
School Garden Association of America.
Southern Society for Philosophy and Psychology.

The total number of scientists that took part in these meetings can only be estimated, as the members of the affiliated and other societies often neglect to register at the desk of the American Association. The number was probably over 500.

There were 428 papers on the program, distributed as follows:

Mathematics and Astronomy	30
Physics	20
Chemistry	16
Engineering	31
Geology	34
Zoology (including Entomology)	111
Botany (including Phytopathology)	108
Anthropology, Psychology, and Education	36
Economics and Social Science	29
Physiology and Experimental Medicine	13
	428

The address of the retiring president, Dr. E. C. Pickering, Director of the Harvard College Observatory, on *The Study of the Stars* was full of interest to every one. I take space to make the following quotation:[1]

The first catalogue of the stars was made by Hipparchus about B. C. 128, and was inserted by Ptolemy in the "Almagest," for fourteen centuries the authority in Astronomy for the world. This catalogue which contained more than a thousand stars, gave both their position and brightness. The earliest copy that is known of the "Almagest" is in the Bibliotheque National in Paris. It is a beautiful manuscript in unical characters of the ninth century. The other later manuscripts unfortunately differ from it and from each other, so that there is some uncertainty regarding two thirds of the stars, owing to errors of copying. A careful study of these discrepancies has been made by Dr. Peters, of Clinton, and Mr. Knobel, of London. Each spent several years on this work, and all the papers are in the hands of Mr. Knobel. He is now preparing the whole for publication and it is hoped that it will be in the hands of the printer in a few months.

A manuscript of nearly the same age is in the library of the Vatican and this year a revised edition of it has been published. If we had a correct copy of the original work, it would have a great value at the present time. Half a century ago it would probably have given the best existing values of the proper motions of the stars which it contained, but recent observations enable us to compute their position in the time of Hipparchus, more accurately than he could observe them, assuming that the motion was rectilinear. This work might, however, throw light on a possible curviture of the motions. The observations by Hipparchus of the light of the stars have a value that will be considered later. . . . .

There are several kinds of variable stars. Variables of long period undergo changes which repeat themselves somewhat irregularly in a period of several months, and at a maximum are often several thousand times as bright as at minimum. . . . .

Variables of short period complete their changes in a few days, or hours. Professor Bailey has found five hundred such objects in the globular clusters. In one of these clusters, Messier 3, out of a thousand stars one seventh are variable, all have a period of about half a day, and their periods are known within a fraction of a second. Their light changes so rapidly that in one case it doubles in seven minutes. It is a strange thought that out of a thousand stars, looking exactly alike, there should be a hundred little chronometers keeping perfect time, and whose rate is known with such accuracy.

Of the many interesting points brought out in the vice-presidential addresses before the sections we can here mention only a few. Professor J. McKeen Cattell, of Columbia University, spoke on *Science, Education, and Democracy*. The following paragraphs are worth attention:[2]

The average salary paid to teachers in the public schools of North Carolina is $199, of Pennsylvania $440, of California $817. The state of

[1] Science N. S. 39: 2 and 7. Jan. 2, 1914.
[2] Science N. S. 39: 161 and 164. Jan. 1914.

Pennsylvania spends on its entire educational system less than one tenth of the value of the coal it mines. When a state consumes its natural resources it should reinvest their entire value in education, scientific research and the public welfare. In 1880 forty per cent. of the teachers in our public schools were men; now the percentage is under twenty; in New England and in New York it is under ten. In Germany four fifths of the teachers are men. . . . .

It is for the honor and ultimate welfare of Georgia that twenty-five per cent. of its population are children of school age, whereas only seventeen per cent. of the population of New England and New York—probably less than twelve per cent of their native population—are of this age. Since 1880 Georgia has increased per-capita payment for public school education sixfold; New York and New England have only doubled theirs. In the past twenty years New York and New England have not increased their expenditure enough to make up for the depreciation in the value of money. Georgia spends each year 6.3 mills on the assessed valuation of its real and personal property on public-school education, New York state 4.7 mills.[2] [[2]Real estate is under assessed in Georgia. In New York personal property is scandalously understated, owing to the tax. Personal property in Massachusetts is valued at more than two thirds of the real estate, and in New York at less than one twentieth.] The south is bent under the inherited burden of slavery and the Civil War. But if it maintains its birth rate and cares properly for its children and its health, the center of wealth and civilization will return southward. . . . .

The progress of the physical sciences in the nineteenth century will in the coming century be paralleled by advances in the psychological sciences. Science and education have given us democracy; it is the duty and privilege of democracy to repay its debt by forwarding science and education to an extent not hitherto known in the world's history.

Before the Botanical Section Dr. D. S. Johnson, of Johns Hopkins University, spoke on *The History of the Discovery of Sexuality in Plants.* He gave a concise and useful review of the development of this problem and of its baffling nature for over 2,000 years to "philosophers" who time and again vainly settled it to their own satisfaction by an appeal to the "nature" of things. Only when philosophy was laid aside and its place taken by direct and accurate observations on plants themselves was progress made. From Dr. Johnson's conclusion we quote the following:[3]

The sexuality which was first suspected, and first experimentally proven, in the seed plants, has now been demonstrated in all groups of plants save the bacteria and their allies. The primary feature of the process, the union of the two parental nuclei, is the same in all. The method of bringing together the two nuclei varies widely, this variation sometimes involving even the complete disappearance of externally recognizable sexual organs. During the evolution of plants old methods of accomplishing the approximation of the nuclei have been discarded, and new methods have arisen. In the latter case a fusion of nuclei of closer kinship has often been submitted for the primitive one of more distantly related nuclei.

[3] Science N. S. 39: 317. Feb. 27, 1914.

This seems evidently the case, for example in the apogamous ascomycetes, perhaps also in the basidiomycetes, and surely so in the cases of nuclear fusion in the prothalia and in the sporangia of apogamous ferns.

The persistent delusion widely current in regard to the scientific value of certain mystical realms of thought and feeling, together with a general misconception of their relation to other phenomena, gives a timely interest to the address of Professor Arthur Gordon Webster on *The Methods of the Physical Sciences, to What are They Applicable?* In discussing " thought transference " he says:[4]

How easy it is for the layman to say, "We know that electromagnetic waves are transmitted in the ether, which we cannot perceive by the senses, why should not waves be emitted by the brain, and be similarly transmitted through the ether?" Why indeed! We may answer him that even if we know nothing more of the ether than the speed of waves through it we know that extremely well, and that whether or not we know the mechanism of the waves (as I conceive that we do) we at least know their differential equations, that is, the mode of their transference. Moreover we have many instruments that are affected by these waves, whereas no one has ever managed, by means of thought waves, to affect the most sensitive instrument, whether torsion balance, quatzfiber, electrometer or galvonemeter. When by taking thought, a mind in this world or the next, shall produce the smallest deflection in an instrument at a distance, then we shall be within the means of a physical investigation. But says the enthusiast, perhaps these waves being not of physical but of mental origin, may be receivable not by physical, but only mental apparatus, and may work only directly on the resonators of the brain. Very well, let us begin with the phenomena that we can control. It is easy to emit brain waves, if such there be. The method described above is then applicable. But if we are in the region of seismic mental waves, there is nothing to do but have our mental resonators always in adjustment and attuned. Then will come the difficulty of discriminating between "strays" and real receptions. How great this difficulty is is shown by the almost vanishingly small results of the societies for physical research so called, and by the delusions from which reputable scientists have suffered. We may here mention the investigations on the celebrated Eusapia Paladino, who certainly secured good indorsements in Europe, but when brought here and examined by a committee including psychologists, physicists, and other detectives, was found to be explicable by purely physical hypotheses.

Among the most important matters of business transacted by the Association was the adoption of the following resolutions:

Resolved, That the council looks with favor upon the organization of a Brazilian division of the Association, and that a committee on organization be appointed for this work with Senator Eduardo Braga as chairman.

Resolved, That the Society of American Forestry be formally accepted as an affiliated society.

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[4] Science N. S. 39: 50. Jan. 9, 1914.

Resolved, That the Council of the American Association for the Advancement of Science authorizes the establishment of local branches of the association in places where the members are prepared to conduct branches which will forward the objects of the association.

Resolved, That the standing committee on organization and membership be instructed to promote the establishment of such local branches.

The president elected for the coming year was Dr. Charles Wm. Eliot, president emeritus of Harvard University.

The next meeting will be held in Philadelphia during convocation week, 1914-1915.

W. C. COKER.

THE ZOOLOGISTS AND NATURALISTS

The American Society of Zoologists and the American Society of Naturalists met with various other biological societies in Philadelphia, December 29 to January 1. The Zoologists and Naturalists held their meeting in the new zoological laboratory of the University of Pennsylvania, a large and handsome building. It may be noted in passing how many universities have recently erected, or are about to erect, elaborate zoological laboratories costing from about $150,000 to $500,000. Princeton, Pennsylvania, Yale, in the East, and the state universities of Ohio, Missouri, and Minnesota, in the West, are in this class.

Important changes in the constitution of the Society of Zoologists, long considered, were fortunately carried through, resulting in the union of eastern and central (middle west) branches of the society. The opportunity still remains for the formation of local sections, wherever ten or more members of the general society can foregather.

The papers read before the Zoologists showed the usual diversity, falling under the heads of comparative anatomy, embryology, cytology, genetics, comparative physiology, ecology. Still other papers were grouped together as "miscellaneous." There were some exhibits, among which may be mentioned photographs of changes in color and pattern undergone by flounders (by Dr. S. O. Mast, of Johns Hopkins, reporting on an investigation carried out at the Beaufort Laboratory) and specimens of several generations of butterflies exhibiting Mendelian inheritance (by Dr. J. H. Gerould, of Dartmouth). Among the

papers which aroused most interest and discussion was one by Dr. Oscar Riddle, of the Carnegie Institution, dealing with the determination of sex through agencies apparently not connected with the chromosomes.

The meeting of the Naturalists included a morning and an afternoon session on December 31 and a dinner at night with the presidential address (by Prof. R. G. Harrison, of Yale). At the morning session several addresses, by invitation of the society, were given dealing with heredity and development. Among these Prof. F. R. Lillie's (University of Chicago) excited especial interest. Professor Lillie described experiments showing that the egg and sperm secrete substances intimately concerned in the process of fertilization. The afternoon was devoted to a discussion of teaching methods. It was brought out that a widespread desire exists to curtail the amount of time given to the study of structure (morphology) and to introduce more experimentation. This is a natural result of the progress of biological science during the past twenty years, and admirably illustrates the close connection between teaching and research, the latter, as it opens up new fields, influencing those conspectuses of phenomena which we call courses of instruction.

H. V. WILSON.

THE FEDERATION OF AMERICAN SOCIETIES FOR EXPERIMENTAL BIOLOGY

For a number of years it has been the feeling of the members of the several scientific societies that are interested in closely related biological problems, that a closer cooperation of these societies was highly desirable.

At the Cleveland meeting in 1912 of the Physiological, Biochemical and Pharmacological societies, committees from these organizations were appointed to consider a plan for the affiliation of the different societies.

The committee consisted of three members from each organization. This committee submitted a plan of affiliation which was adopted at the meeting of the various societies in Philadelphia in December.

The plan as proposed by the committee consists in the formation of an organization composed of the American Physiological, the American Biochemical and American Society for Pharmacology and Experimental Theraupeutics. The organization of the affiliated societies is to be known as The Federation of American Societies for Experimental Biology.

At the December meeting the Federation was strengthened by admitting to membership the recently formed Society for Experimental Pathology.

As a result of this union an organization has been founded which has about 450 members.

It is hoped that the Naturalists, Zoologists, and Anatomists will meet with the Federation. Such was the case at the recent Philadelphia meeting.

It is not the object of the Federation that the several societies should in any way lose their identity, the different societies composing the Federation elect officers and conduct their meetings as usual. It is hoped, however, that by having joint meetings and that by the members of the different societies coming to know personally their co-workers that the efficiency of the various organizations will be increased and that the members of the different societies will find in the Federation a wide usefulness for the " promotion of research and the dissemination of truth."

The meeting in Philadelphia was notable for the number of members attending, the number and general excellence of the communications presented, and for the very enjoyable social gatherings in the form of the " dinners." In addition to these features the program committee very wisely allotted an afternoon session to be used for demonstrations.

The physiological and other demonstrations were given in the Pharmacological Laboratory of the University of Pennsylvania. The experiments were well planned, were unusually successful and constituted one of the most enjoyable and instructive features of the meeting.

The two demonstrations which likely aroused the most interest were conducted by Professor Abel and his associates and by Dr. Meltzer and Dr. Gates.

Professor Abel, Dr. Rountree and Dr. Turner demonstrated an apparatus for "Vividiffusion."

The apparatus consists in a large glass cylinder in which is a series of celloidin tubes. Surrounding the celloidin tubes different diffusion fluids may be used; salt solutions of different strength or glucose solutions. The celloidin tubes which are dialyzing tubes are attached at their ends to glass tubes. The latter are connected by rubber tubing with the animal used in the experiment.

An animal, preferably a dog, is anesthetized and glass canulas are placed in the caroted artery and jugular vein. The canula from the artery is connected with the intake tube of the diffusion apparatus and the canula in the vein is connected with the remaining glass tube which leads from the diffusion apparatus. By such a scheme blood passes from the animal through the arterial canula into the celloidin dialyzing tubes, through these tubes and back into the animal through the canula in the jugular vein.

In order to prevent the blood from clotting during the time it is in the celloidin tubes a solution of hirudin (leech extract) is injected into the arterial canula.

The use of such an apparatus opens a new field in the study of metabolism of the body in general, in the study of the metabolism of isolated organs, and in the removal from the body of a living animal of various toxic bodies. Used in the latter sense the apparatus will likely serve as a valuable therapeutic agent.

The demonstration by Dr. Meltzer and Dr. Gates consisted in showing the antagonism which exists between the salts of magnesium and calcium.

A rabbit was anesthetized by injecting a solution of magnesium salts. The anesthesia was profound. An injection of calcium salts was then made into the lateral ear vein of the animal. Within a very few seconds following the injection, consciousness had completely returned, the animal appearing in all respects normal.

The scientific communications presented at the meetings of

the various societies forming the Federation were of unusual interest and of very high grade.

The meetings came to a close on December 31st, 1913, at which time the first executive session of the Federation was held. At this meeting the feeling of the Federation concerning animal experimentation was expressed and adopted in the following form:

1. We, the members of the Federation of American Societies for Experimental Biology—comprising the American Physiological Society, the American Society of Biological Chemists, the American Society for Pharmacology and Experimental Therapeutics and the American Society for Experimental Pathology,—in convention assembled hereby express our accord with the declaration of the recent International Medical Congress, and other authoritative medical organizations, in favor of the scientific method designated properly animal experimentation but sometimes vivisection.

2. We point to the remarkable and numerable achievements by animal experimentation in the past in advancing the knowledge of biological laws and devising methods of procedure for the cure of disease and the prevention of suffering in human beings and lower animals. We emphasize the necessity of animal experimentation in continuing similar beneficient work in the future.

3. We are firmly opposed to cruelty to animals. We heartily support all humane efforts to prevent the wanton infliction of pain. The vast majority of experiments on animals need not be, and in fact, are not accompanied by any pain whatsoever. Under the regulations already in force, which reduce discomfort to the least possible amount and which require the decision of doubtful cases by the responsible laboratory director the performance of those rare experiments which involve pain, is we believe, justifiable.

4. We regret the widespread lack of information regarding the aims, achievements and procedures of animal experimentation. We deplore the persistent misrepresentation of these aims, achievements and procedure by those who are opposed to this scientific method. We protest against the frequent denunciations of self-sacrificing, high-minded men of science who are devoting their lives to the welfare of mankind in efforts to solve the complicated problems of living beings and their diseases.

WM. DEB. MACNIDER

THE BOTANICAL SOCIETY OF AMERICA

The Botanical Society of America met in Atlanta, in affiliation with the American Association for the Advancement of Science. About ninety members were present and a large program of fifty-five papers was offered. Among these we have space to mention only a few. Discussing the trend and influ-

ence of certain Phases of Taxonomy, Professor Aven Nelson said:[5]

> We are on the eve of a new era of reconstruction. Already the pendulum is swinging back toward greater conservatism. The dismemberment of genera and the multiplication of species proceed more cautiously. This grows out of the revitalized aim, "Make it easier for others to know plants."

The perplexity of the systematist may be understood when we consider the increasing evidence of numerous distinct strains within "species" whose characteristics are inherited and apparently well fixed. Such strains were reported by Mr. Chas. A. Shull in the cockle-burr, *Xanthium canadense,* and Professor A. F. Blakeslee showed that in cultures from a single spore of a species of *Mucor* variation occurred that retained their characters for some time. Of their variation he says "Many of them would undoubtedly be described as distinct species in the group."

Experiments by Mr. Jacob R. Schramer with seven species of green algæ gave no evidence of any power to fix free nitrogen.

Professor W. J. V. Osterhout reported as follows:[6]

> Van't Hoff's formulation of the laws of chemical dynamics has proved so stimulating to various fields of chemistry that it may be expected to be similarly useful if it can be applied to the activities of living protoplasm. The writer finds that by measuring the electrical resistance of living tissues it is possible to follow the progress of reaction in protoplasm in the same way that Van't Hoff followed the progress of reactions in vitro. It therefore becomes possible to apply Van't Hoff's methods and formulae directly to protoplasm in its living and active condition.

Professor Osterhout also finds that by means of electrical measurements of living tisues it is possible to predict which salts will antagonize each other when allowed to act upon these tissues.

Dr. R. H. True advocated the use of "normal physiological solution" for experimental purposes, rather than distilled water, which cannot, in practice, be obtained pure, and which moreover has been found to be injurious to certain plants, probably by absorbing from their roots some of the constituents necessary to the maintainance of life activities.

[5] Science N. S. 39: 255. Feb. 13, 1914.
[6] Science N. S. 39: 292. Feb. 20, 1914.

The most important matter of business that came before the Society was the report of the committee on the new botanical journal. This provides for a co-operative arrangement with the Brooklyn Botanic Garden which has made possible the immediate publication of the journal. This publication is known as the *American Journal of Botany* and it will be sent to all members of the Society. The first issue for January 1914 has already appeared. It will do a great deal to relieve the congestion of material that now exists in the sources of publication in this country.

Mr. A. S. Hitchcock, the well known agrostologist of the U. S. Department of Agriculture was elected president for the ensuing year.

W. C. COKER.

ABSTRACTS AND REVIEWS

THE TWENTY-SEVEN LINES UPON THE CUBIC SURFACE

The contributions which Dr. Henderson has, from time to time, made to the study of the cubic surface, were some time ago embodied in this able work.[1] The following review, though belated, purports to give a brief sketch of Dr. Henderson's work. The mere fact that it enjoys the distinction of being the second work by an American professor in this series of Cambridge University Memoirs bespeaks its quality. The other American professor to be thus honored was Dr. Maxine Böcher, of Harvard University.

In his Introduction, Dr. Henderson says: "In this memoir is given a general survey of the problem of the twenty-seven lines, from the geometric standpoint, with special attention to salient features: the concept of trihedral pairs, the configuration of the double six, the solution of the problem of constructing models of the double six configuration and of the configurations of the straight lines upon the twenty-one types of the cubic surface, the derivation of the Pascalian configuration from that of the lines upon the cubic surface with one conical point, and certain allied problems." Some of the principal results of the author's researches have been presented in papers read before the American Mathematical Society, the North Carolina Academy of Science, and the Elisha Mitchell Scientific Society. Furthermore, some conclusions have been incorporated by the author in the following papers, published within recent years: "On the Brianchon Configuration," *American Mathematical Monthly,* 36-41; "On the graphic representation of the projection of two triads of planes into the mystic hexagon," *Journal El. Mitch. Sci. Soc.,* 20:124-133, 1904; "A Memoir on the twenty-seven lines on the cubic surface," *Journ. El. Mitch. Sci. Soc.,* 21:76-87, 120-133, 105.

As Dr. A. C. Dixon has pointed out in the *Mathematical*

[1] The twenty-seven lines upon the cubic surface by Archibald Henderson. Published by the University of Cambridge, at the Cambridge University Press, London.

Gazette, the central problem attacked by Dr. Henderson is a fascinating one; and the author has solved the problem in a completely satisfactory and exhaustive way. The beautiful plates, thirteen in number, showing in perspective representation the lines on all twenty-one different types of the cubic surface, express the solution in concrete form. Noteworthy is the author's analytical investigation of the double-six theorem, which is both simple and self-contained.

It is to be noted that the author does not refer to Cremona's well-known form of the cubic, nor to the parametric representation of a variable point on the surface. To do so would doubtless have carried him too far afield, since this is not a treatise on the cubic surface, but the study of a particular configuration associated with it. The listing of the trihedral pairs seems to be carried out at needless length, until it is observed that they serve as the basis for subsequent conclusions. Especially noteworthy is chapter VII, dealing in an elegant manner, both analytically and geometrically with certain configurations associated with the configurations of the lines upon the cubic surface.

There is a long and valuable bibliography of the general literature in all languages in regard to the lines upon the cubic surface. It is all the more valuable in that it is, strangely enough, in view of the importance of the subject, the only one which has ever been compiled. The following title might profitably be added to this biblography: "Beziehungen der allgemeinen Fläche dritter Ordnung zu einer covarienten Fläche dritter Classe," by Th. Reye, *Math. Annalen,* Bd. LV.; "Ueber einige Eigenschaften der allgemeinen Fläche dritter Ordnung," G. Kohn, *Wiener Sitzungsberichte,* Bd. cxvii; and Professor W. W. Burnside's recent paper in the *Cambridge Philosophical Proceedings* on double-sixes with projective transformations.

The two great English geometers, C. Salmon and A. Cayley, first studied the theory of straight lines upon a cubic surface in correspondence, subsequently published in 1849. In 1873, Cayley devised a method for constructing a double-six, but achieved only theoretical success in his effort to construct a model of the configuration. The significance of Dr. Hender-

son's work is that he has satisfactorily completed this work left unfinished by Cayley, and generalized it so as to apply to the complete configuration of all the lines upon each of the types of the cubic surface. This volume, as expressed in a recent review in *Nature,* is "carried through with great earnestness, and so far as possible with the simplest materials; its obvious sincerity cannot fail to be inspiring to anyone who will be at pains to understand it. The author's assembling of his materials for the constructions which follow, and the very want of useless elaboration is a proof of the independence with which the author has carried out his research."

WILLIAM CAIN.

DEVELOPMENT OF SPONGES FROM DISSOCIATED TISSUE CELLS

In this paper[2] the author, Dr. H. V. Wilson, presents in full detail the facts in his study of the restitution of sponges from dissociated cells. Precise information as to methods is also given. The larger part of the illustrations are photographs, chiefly at low magnification. The latter show the sponges as grown on slips of glass. As the writer mentions the sponges present many points of superficial similarity to myxomycete plasmodia. It is noteworthy that the method employed has proved to be one by which large numbers of sponges may be easily grown. Mr. R. R. Bridgers, at the time a student of this University, served as Professor Wilson's assistant and during one summer carried more than a hundred sponges to a stage where they were quite similar to normal sponges as one collects them in Beaufort harbor. A point of particular interest is that a number of Mr. Bridgers' sponges went so far as to produce embryos at the end of the season. From this standpoint the method seems promising for the study of the general question of embryo formation in sponges and quite possibly for the experimental determination of the conditions under which the sex elements are produced.

It is of interest to know that other investigators have shown that Professor Wilson's methods are applicable to fresh-water

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[2] Bulletin of the Bureau of Fisheries, Volume XXX, 1910.

sponges and calcareous sponges. Karl Muller[1] has succeeded in growing Spongillas from dissociated cells. And Julian S. Huxley,[2] working at Naples, also succeeded in developing *Sycon raphanus* in the same way.

W. C. GEORGE.

ON THE BEHAVIOR OF THE DISSOCIATED CELLS IN HYDROIDS

In this paper[3] Dr. H. V. Wilson shows that hydroids may likewise be grown from dissociated cells. The methods practiced were essentially the same as those used for sponges. The hydroids, however, proved far more difficult objects to handle. Nevertheless, hydropolypes (Eudendrium, Pennaria) were developed with the characteristics of the species. Here again the methods may prove of use in studies of the origin of sex. In this paper Professor Wilson considers his observations more directly than in preceding papers from the standpoint of the reduction theory. He points out that in sponges this question is complicated by the presence in the sponges of large numbers of undifferentiated cells (amoebocytes). But in hydroids, such cells are present in a negligible quantity, and the restitution masses, therefore, undoubtedly are derived from the differentiated ectoderm and entoderm cells. These cells after dissociation lose their distinctive histological characteristics and combine to form a solid mass which again differentiates like a coelenterate embryo into ectoderm, entoderm, and a central yolk. These facts then certainly lend great weight to the idea that differentiated somatic cells may undergo a process of regressive differentiation (reduction), and pass into a generalized state physiologically similar to embryonic tissue.

W. C. GEORGE.

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[1] *Das Regenerationsvermögen der Suswasserschwämme, insbesondere Untersuchungen uber die bei ihnen vorkommende Regeneration nach Dissociation und Reunition.* Archiv F. Entwicklungsmechanik der Organismen, 32: 397-446. 1911.

[2] *Some Phenomena of Regeneration in Sycon; with a Note on the Structure of Its Collar-cells.* Philosophical Transactions of the Royal Society of London. Series B, 202: 165-189. 1911.

[3] The Journal of Experimental Zoology 11: 281-338. 1911.

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THE OCCURRENCE AND UTILIZATION OF CERTAIN MINERAL RESOURCES OF THE SOUTHERN STATES*

BY JOSEPH HYDE PRATT

There are many minerals being mined in the Southern States, the individual production of which is comparatively small, but whose total production is several millions of dollars. The minerals of this group with which this paper briefly deals are: Gold and silver, graphite, talc (soapstone), barytes, chromite, corundum, rutile, and a group of minerals that are directly associated with pegmatite, as mica, feldspar, kaolin, quartz, beryl, uranium minerals, monazite, zircon, gadolinite, samarskite, and cassiterite.

There are a number of the nonmetallic minerals that have played an important part in the commercial history of the South, and certain of the Southern States now have such a reputation that if a commercial demand arises for a certain mineral that has formerly been considered rare in its occurrence, prospecting is at once begun for it in certain of these States.

Among the minerals that were at one time considered rather rare in their occurrence, but upon a demand arising for them in the arts have been found in commercial quantity in one or more of the Southern States are: Corundum, monazite, zircon, gadolinite, and bauxite. There are several more of the nonmetallic minerals that are closely connected with the economic history of the South, principally mica, salt, and sulphur, but only the first one will be considered in this paper.

* Paper read before Section E, Geology and Mineralogy of the American Association for the Advancement of Science, at the Annual Meeting held in Atlanta, December, 1913.

Some of these minerals are peculiar to the states in which they are being mined, as monazite in North Carolina and South Carolina, rutile in Virginia, zircon in North Carolina, gadolinite in Texas, samarskite in North Carolina.

GOLD [1]

The first authentic account of gold having been found in the Southern States was in 1797 when a 17-pound nugget was found on the Reed plantation in Cabarrus County, North Carolina. This caused a systematic search to be made for this metal not only in North Carolina but in the adjoining States, which resulted in the finding of a large number of nuggets and was the beginning of gold mining in the South. By 1825 gold mining was being very vigorously carried on along the eastern slopes of the Blue Ridge from Virginia to Alabama. The discovery, however, of gold in California in 1849 and the exhaustion of the easily worked placer deposits had a decidedly retarding influence on gold mining in these states, and, with the breaking out of the Civil War in 1861, it practically came to a standstill. Stories and reports of the value of the gold that was obtained continued to be spread abroad and, as the years went by, they lost nothing in the telling, and the unsuspecting hearer was given an idea of untold wealth left in these mines. The results were that unscrupulous promoters made the most of these old stories and reports for furthering schemes for the disposal of stock in mining properties that had little or no merit; and that many investors have expected all mining properties to be bonanzas. Failure to realize what had been expected caused a rather general condemnation of all mining propositions throughout the South, and it is only within the past few years that a reaction has set in and the general public has been able to look squarely and impartially at conditions as they really exist.

The successful development of one or two good properties and the publication of reliable reports regarding the general mineral resources have finally awakened a confidence not only in the gold mines of the South but in all kinds of mines.

[1] Bulls. 3 and 10, North Carolina Geological and Economic Survey. 1896 and 1897. Bull. 4-A Georgia Geological Survey. 1896.

There is a large area in the South Atlantic States throughout which gold has been found in more or less quantity. The greatest width of this area as a whole is attained in North Carolina, South Carolina and Georgia, where it is from 100 to 150 miles, narrowing down in Virginia and Maryland on the northeast and in Alabama on the southwest. This area includes a large portion of the mountain and piedmont regions and their crystalline rocks consisting of gneisses, argillaceous, hydromicaceous, chloritic, siliceous and other schists and slates; limestone, granite, diorite, diabase, and other eruptives as well as certain volcanic porphyries. This area extends practically to the coastal plain region and is bordered on the west by the Paleozoic rocks.

The gold deposits that are distributed throughout this area can readily be divided into three general classes according to their occurrence:

1. Placer deposits.

2. Quartz veins, either true fissure or replacements, carrying either free gold or gold-bearing sulphurets.

3. Impregnations of free gold or finely divided sulphurets in the country schists and slates, or replacement portions of these.

The gold found in the placer deposits is free gold and has been derived by the alteration and erosion of the other two types of ore deposits. These placer deposits represent a natural concentration of the gold that was formerly in the vein or country rock and, therefore, these deposits are relatively richer or of higher value than the veins or ore deposits from which they have been derived. There are but very few streams flowing through this area but the gravels of these would pan from one or two to several colors of gold. In many instances, by following up the placer deposits the veins have been encountered and, where these carried free gold, they have been extensively worked. Often it has been found that the veins themselves were too low grade to be worked profitably, although the placer deposits were remunerative.

The richer portions of the first type of ore deposits have been pretty thoroughly worked out, but there are still areas of gravel

deposits that can be worked profitably with proper management. There are many good deposits of the other two types that carry sufficient values to make mining profitable.

The gold area of the Southern Appalachian Region has been divided into the following belts:

Virginia belt.
Southern Carolina belt.
Carolina belt.
South Mountain belt.
Georgia belt.
Alabama belt.

Of these the Carolina and Georgia belts are by far the most important.

In the Carolina belt of North Carolina and South Carolina the area is about equally divided between igneous and sedimentary rocks. The eastern portion comprises the great series of sedimentary slates, interbedded in which are irregular bands and long lenses of volcanic rocks, representing tuffs, breccias and flows, of which there are two types, rhyolitic and andesitic. The western portion is made up wholly of igneous rocks. These are of three general types—greenstone, diorite, and granite—together with numerous dikes of both acid and basic character, each type showing more or less variation and local differences. In a general way, it may be said, taking the rocks in order of their relative ages, that the greenstone with its local tuffaceous phases, is the oldest and most highly metamorphosed rock in the area, the diorite next in order and the granite least of all. There are at least four types of rock occurring as dikes. The oldest dikes are of diorite, which cut the greenstone only. Following this series, are the granite and quartz-porphyry dikes, which cut both the greenstone and the diorite; next in order are the fine-grained diorite dikes, which cut both the granite and the diorite; and last is the series of diabase dikes, probably of Triassic age.

The region has suffered a period of severe dynamic metamorphism or mashing, consequent upon a great compressive force which squeezed the beds into enormous folds; followed by a time of chemical alteration and mineralization; which in

turn was succeeded by a long period of erosion and weathering. The rocks have suffered to a variable degree from all these factors. In general, each formation has a massive and a mashed or schistose phase, with every gradation between the two. The passage of heated solutions has affected all formations, as evidenced by the mineralized zones, the abundance of quartz veins, and the high degree of silicification in many belts of rocks, and the universal occurrence of infiltrated iron ores. Finally, erosion has planed off all the upper portion of the folded series; but weathering has proceeded in excess of erosion to such an extent that the region is now deeply decayed, so that only here and there do the rocks project through a thick mantle of decomposed rock or soil.

In the Georgia belt [2] the rocks are of Archæan micaceous and hornblendic gneisses and schists and probably represent the sheared granitic and dioritic rocks. These gneisses and schists are banded in narrow lenticular-shaped layers, from two to twenty feet wide. A dark-colored schistose hornblende rock, locally known as "brick-bat," is of frequent occurrence. Its structural relations are very difficult to determine; at times it is conformably interlaminated with the other schists (as at the Hedwig mine, near Auraria); again, it appears to have no regular relation in its position to the adjoining schists, which are cut off by it or very markedly disturbed in their strike, bending around the "brick-bat" mass, and developing a crumpled or folded structure in the schistose laminæ (as at the Singleton and Lockhart mines, near Dahlonego). It is possible that these "brick-bat" masses, which appear to be dioritic in origin, are magmatic segregations or blebs, similar to the pyroxenic and hornblendic blebs of the South Mountain region of North Carolina, though, as a rule, larger. The prevailing strike of the gneisses and schists is north 20°-30° east, and the dip 30°-60° southeast. Locally, however, in the presence of the dioritic masses, this changes to northwest strikes with northeast dips. The rocks are often garnetiferous and contain rarer accessory minerals, such as monazite, though to a much lesser

[2] Bull. 10, North Carolina Geological Survey, 1897, pp. 21-22.

degree than in the South Mountain rocks. The depth of the saprolites in the Georgia belt reaches a maximum of about 100 feet.

Diabase dikes, such as are common in the Carolina belt, are not found in the Georgia belt. Granitic dikes are, however, not uncommon in the Nacoochee region.

SILVER

There is very little silver alloyed with the gold that is mined in the Southern States, but there are in the Carolina belt a few deposits which contain a definite silver ore. This is represented by what is known as the Silver Hill type of Ore Deposits, in which the ores consist of a complex mixture of gadolinite, sphalerite, pyrite, chalcedony, and quartzose gangue, or as narrow stringers in the schists with little or no gangue.

Most of the silver credited to the Southern States is obtained from copper ores, and therefore its production varies, as the production of copper changes. It is obtained principally from Tennessee with smaller amounts from North Carolina and Virginia.

GRAPHITE

Graphite has been produced in Alabama, Georgia, and North Carolina; but it is only in the former state that the production has been of any very large commercial value. That produced in Georgia is not used for the ordinary purposes for which graphite is desired. This graphite, which only contains a comparatively small per cent of carbon, is used as a filler in the manufacture of fertilizer.

In a number of the states, as in the North Carolina deposits of Wake and McDowell counties, the graphite occurs in schistose rocks, constituting from a small quantity up to 25 per cent or more of the rock. The occurrence of mica and some silica in these schistose rocks makes it difficult to separate a pure graphite from them. The Georgia graphite deposits, which have been producing rather extensively for the last year or two, are in the nature of a graphite shale or slate, containing approximately 13 per cent of graphite. These deposits are located near Emer-

son, Bartow County, and the product mined is used as a colorer in the fertilizer trade. The material is not cleaned in any way, being simply pulverized so that 60 per cent of it will pass through a 24-mesh screen and all through an 8-mesh screen. The value of this material is, of course, very low, and in the total production of graphite in the United States it has increased the tonnage material without adding very largely to the value.

The graphite produced in Alabama is the crystalline variety. As described by Mr. E. S. Bastin:[3] "The graphite is widely distributed among the metamorphic rocks of Alabama, in which it occurs in two forms: (1) In the feebly crystalline schists which have been called the Talladega slates, and which in part at least are Paleozoic sediments of as late age as the "Coal Measures," graphite is often found as a black graphite clay free from grit. In this condition the graphite is difficult to separate from the other matter with which it is mixed and the material has not as yet been utilized commercially to any important extent. Examples of this mode of occurrence may be seen near Millerville, in Clay County, and about Blue Hill in Tallapoose County. (2) In the mica schists and other highly crystalline rocks graphite is found in the form of thin crystalline flakes which may be separated from the associated minerals. Graphitic schists of this type are now being worked at three localities and have in the past been worked at several others."

One of the most interesting graphite deposits in North Carolina is one in Alexander County, about 5 miles from Taylorsville.[4] The properties upon which this graphite has been found are first encountered about 5 miles a little south of west from Taylorsville on the eastern and northeastern slopes of Barretts Mountain, and graphite has been observed at intervals for a distance of over two miles in a direction a few degrees west of South.

The country rocks are schists and gneisses, cutting through which are pegmatitic dikes varying from a few inches to five (5) feet or more in thickness. The graphite occurs in these

[3] United States Geological Survey. Mineral Resources 1910, p. 903.

[4] Economic Paper 6, North Carolina Geological Survey, 1902, pp. 71-72.

pegmatitic dikes and is in the form of small particles and nodules from a fraction of an inch to six or more inches in diameter. Wherever these pegmatitic dikes have been observed, they have been badly decomposed and but very little fresh feldspar has been observed in them. The graphite is of good quality, some being of a nearly crystalline character. In the deeper working there was but little of the graphite stained with iron oxide. On breaking open the nodules of this mineral, they were found to be nearly pure, and on testing them, no grit was observed. The quality of the graphite seems to be uniform whereever encountered along this belt, although, of course, some variation was noted in the percentage of that stained with iron oxide, according as it was found near the surface, or at some distance below. There is considerable variation in the percentage of graphite in these pegmatitic dikes, and it will not average over a few per cent. In some places, however, where the large nodules of graphite were found, the percentage was as high as 50 or 60 per cent. The graphite is readily separated from the decomposed dikes, and where it occurs in nodules of an inch or over in size, a product can be obtained by hand-cobbing that is composed of 90 per cent or over of graphite. No work has been done of sufficient depth so that the unaltered pegmatitic dikes were observed, but in one opening the dikes were observed that were but partially decomposed. If in depth the graphite remains a constant constituent of these pegmatitic dikes, it should be found in a very pure condition as the solid dike is encountered and it should not be a difficult problem at all to make a clean separation of the graphite from the associated minerals of the dike. These pegmatitic dikes are dipping from 30 to 50 degrees northwest and have a general strike a few degrees east of north. They follow for the most part the lamination of the rocks, but sometimes are cutting across them. They vary considerably in width, widening and contracting in short distances.

TALC [5]

Commercial deposits of talc have been found in Virginia,

[5] Mineral Resources United States Geological Survey, 1900-1905 inclusive; Economic Paper 3. North Carolina Geological Survey, 1900.

North Carolina, and Georgia. The better and more valuable variety has been found in North Carolina.

The Virginia deposits are for the most part the stealtite variety of talc, and this State is the most important producer of soapstone in the United States. Seventy-eight per cent of the product that is mined is manufactured into laundry tubs and similar objects.

In North Carolina and Georgia, especially in the mountain areas of these states, there are large areas of soapstone; but on account of their distance from railroads, they have not been developed. Recently a deposit of compact talc was found in Ashe County which gives promise of producing a talc that can be used for talcum powders and other purposes that require a ground talc.

The Georgia and North Carolina deposits of talc are somewhat similar in their occurrence. Those in the latter state furnish the finest grade of talc produced in the United States. The formation in North Carolina in which this talc is found begins in Swain County, about 6 miles east of the Valley River Mountain, follows up the valley of the Nantahala River to near the Macon County line, thence ascends the Nelson Creek ravine and crosses the mountains at an altitude of 2,800 feet at Red Marble Gap. Entering Cherokee County, it follows Valley River, broadening out near Andrews to a width of about one-half of a mile; then crosses the Valley River and the Hiwassee River and Valley in the vicinity of Murphy, and follows the Nottely River Valley, crossing the State line into Georgia.

All the deposits are located either alongside the railroad or in close proximity to it. The Murphy branch of the Southern Railway passes over the formation for almost the entire distance from its eastern end to Murphy. To the west of Murphy the Atlanta, Knoxville and Northern Railroad follows close to the talc and marble outcrops. Facilities for railway transportation at nearly all the deposits are of the best and but little hauling by wagon is necessary, 2 miles being the longest distance from a shipping point on the railroad.

The rocks of the talc-bearing region in these southwestern

counties are for the most part marble and quartzite, bordered by gneiss and crystalline schists. Repeated dynamic movements have twisted and folded the strata to such an extent that their original structure has been almost wholly obliterated, and in many cases it has changed considerably their mineralogical character. Part of the limestone has been metamorphosed and recrystallized into compact marbles of the finest quality, while the sandstone has been converted into a quartzite which at times is almost without perceptible granular structure.

So far as these beds of marble have been examined, they are for the most part free from layers of silicates or quartz, except, of course, those in proximity to the contact with the quartzite. Near the contact, but in the marble, nearly pure white tremolite in prismatic crystals as large as a quarter of an inch in diameter has been found. The limestones which were first laid down and which were subsequently covered by the sandstone can be traced from about a mile east of Hewitts, Swain County, in a southwest direction across Swain, Macon, and Cherokee counties into Georgia. The width of this marble belt varies from a few hundred yards to over half a mile along Valley River, near Andrews, Cherokee County. The Valley River mountain ridge, the boundary between Macon and Cherokee counties, is an anticlinal fold, with a northwest-southeast trend which marks rather sharply in some respects the character of certain formations to the northeast from those to the southwest. East of this ridge the marble quartzite formation is bounded on the north and south by a slate, while west of this ridge this formation is bounded on the south by crystalline schists and slates, on top of which are numerous beds of limonite. The depth of the stratum of marble has not been determined, but it is known to be over 100 feet.

The strata dip at all angles, due to their being repeatedly folded, but have a general trend of about N. 35° E.

It is in connection with this marble formation that the deposits of talc occur. What was formerly supposed to be a regular vein of the talc was probably a series or pocket of this mineral of varying thickness, lying for the most part directly

between the marble and the quartzite, although at times entirely enclosed by the marble. No pockets, however, have been observed that were inclosed by the quartzite. These pockets, which resemble in shape flattened lenses, always follow the dip of the strata in which they occur, and are therefore encountered in all positions from horizontal to vertical.

These pockets of talc were once much more abundant than now. At the present time the only evidence as to the former existence of many of these is the occurrence of a bluish clay containing a few scattered flakes of talc. Wherever the quartzite capping of the pocket of talc has remained the talc is in a good state of preservation, but, on the other hand, wherever the quartzite has been removed by disintegration and erosion the talc has been either partially or wholly decomposed into the bluish clay. In places the talc is found wholly surrounded by the marble, as at the Kinsey mine where small pockets or lenses of it are in the marble, but still close to the contact.

The beds of limonite iron ore are found closely associated with the marble and talc deposits between the Valley River mountains and the Nottely Valley. The iron ore, which always lies to the south of the talc, is sometimes almost in direct contact with it. The yellow stains observed upon so much of the talc in this region are undoubtedly due to its proximity to the iron ore. Although there are a number of iron-ore deposits in the Nottely River Valley, they are not in close proximity to the talc and marble, and have exerted but little influence upon the character of the talc. It is in this valley that the most beautiful talc has been found.

Folding and subsequent erosion of the strata have brought the marble and talc to the surface at a number of points along the valleys of the Nottely and Valley rivers and on the slopes of some of the adjacent ridges. In the broader portions of the valleys the marble and talc are often covered by an alluvial soil which in places reaches a depth of from 20 to 30 feet.

In Georgia the talc deposits are practically limited to Murray, Fannin, Gilmer, and Cherokee counties. In all, except Murray, the deposits are associated with Murphy marble. Soap-

stone of varying grades of purity is found in almost every county in the Piedmont area of the State.

Pyrophyllite, a hydrous aluminum silicate, which has many of the physical properties of talc, is being mined in North Carolina and is used for many of the purposes for which talc is produced.

The pyrophyllite (agalmatolite) deposits are located in the extreme north central portion of Moore and the south central part of Chatham counties, and can be traced across the country for a distance of eight miles. The principal mining that has been done is near the boundary between the two counties in the vicinity of Glendon, Moore County. They are associated with the slates of this region but are not in direct contact with them, being usually separated by bands of siliceous and iron breccia, which are probably 100 to 150 feet thick. These bands of breccia contain more or less pyrophyllite, and they merge into a stratum of a pyrophyllite schist. Between this and the massive beds of pure pyrophyllite there are very often small seams of quartz and larger lenticular quartz masses, several feet thick.

The strike of this formation is approximately N. 55°-60° E. and dipping 60°-70° to the northwest. It is first encountered about three and three-fourth miles southwest of C. H. Womble's house, and three and one-fourth miles beyond Deep River. Where the formation crosses the river there is a good outcrop of pyrophyllite, and then at a point 100 yards to the northeast and extending for about half a mile, the mineral has been mined at intervals. Beyond this point, which is near Rogers Creek, there has been no mining, but the formation can be followed for another three miles to the northeast. In this distance there are many promising outcrops of the pyrophyllite.

The beds of this mineral are not entirely of commercial quality, but there are bands of the pyrophyllite that are highly siliceous alongside of those that are entirely free from grit. Although the general appearance of the waste and good material is very similar, they can readily be distinguished by the touch, and can therefore be readily kept separate by hand cobbing.

Small seams of quartz often penetrate into the beds of pyro-

phyllite, cutting across the bedding of the formation, while those between this and the brecciated rock or schistose rock are parallel with the strike.

Besides the quartz as an impurity, portions of the deposit are filled with small particles, some of which are chlorite, and others hematite, giving them a decided speckled appearance. These portions vary from seams a few inches in width to lenses several feet thick.

A cross section of these beds will probably not show an average of over twenty-five to thirty per cent of commercial pyrophyllite.

The pyrophyllite rocks have a width of about 500 feet, but not over 100 feet of this would constitute the workable deposits, and of this but twenty-five per cent would be of commercial pyrophyllite. This, however, is so located that not over fifty feet would have to be mined to obtain the twenty-five feet of good number-one material.

While the talc deposits of Cherokee and Swain counties are pockety in nature and of limited depth, the pyrophyllite formation is continuous and of considerable, though of unknown depth.

BARYTES

This mineral, which is mined somewhat extensively in Virginia, North Carolina, South Carolina, Georgia, Tennessee and Missouri is usually associated with limestone. There are, however, in North Carolina and South Carolina deposits that are interesting on account of a decidedly different occurrence.

These barytes deposits that occur in a line running N. E. and S. W. from Kings Creek, York County, South Carolina, to the North Carolina line, and near Crowders Mountain, Gaston County, North Carolina, are very similar in their occurrence. The barytes occurs in lenticular masses whose strike and dip conform approximately to the strike and dip of the schistosity of the schists in which they are found. The barytes very probably represents the filling of fissures and crevices in the schist which may have been caused by the faulting and tearing apart of the schist. These are lenticular in outline, pinching or nar-

rowing to minute seams along the strike and also in depth. These lenticular veins, however, may be found to be 100 or more feet in depth and then be connected by a narrow seam with still another. They are known also to occur from 100 to 400 feet in length and then be connected by narrow seams, or be adjacent to other lenses of barytes. The deposit does not always represent a solid vein, but is more apt to contain a main seam of barytes with smaller seams on either side and approximately parallel to them, the different seams of barytes being separated by bands of the schist rock. The general strike of the schist and also of the barytes veins is in a general N. E. and S. W. direction and they are pitching at very steep angles. There is usually accompanying the barytes more or less quartz, which, however, is found either on one side or the other of the seam of barytes. Occasionally it is intermixed with the barytes; then again, the fissures and crevices may be filled almost entirely with quartz with little or no barytes, but the quartz can usually be traced almost continuously for long distances in the direction of the strike of the schists and seams. Thus, at nearly every opening in which barytes has been found, quartz was the mineral that outcropped on the surface, the barytes being encountered a few feet below and to one side of the quartz.

RUTILE

The only rutile that is mined in this country is at Roseland, Virginia.[6] The rutile occurs in irregular bunches in a gneiss that rises in a bluff 40 to 50 feet above the Tye River and has been mined in four open quarries for a length of about 300 feet. Along this bluff the ore occurs in very irregular masses, some of it being nearly pure dense white feldspar with streaks and patches of rutile, and at other times in the form of small grains about the size of wheat. This ore yields about 5 per cent of rutile. Occuring in both the ore and the gneiss are seams and specks of opalescent blue quartz about one-half an inch across. At the lower or southeast end of these workings the ore contains about 10 per cent of rutile, but it also contains manaccanite which cannot be removed by the present method of concentration; but

[6] Virginia Geological Survey, Bulletin III-A, 1913.

with the introduction of a magnetic concentrator, can be eliminated. Mining was begun at this locality in 1900, and has continued to the present time.

Rutile has also been found in North Carolina, South Carolina, Georgia, Alabama, and Arkansas but not in commercial quantity. It has been obtained in a limited amount both in North Carolina and Georgia and used for gem purposes. North Carolina rutile of gem quality has been found at the smoky quartz and hiddenite localities of Alexander County; near Efland, Orange County, where it is associated with beautifully radiated pyrophyllite. Large rough black rutile crystals in considerable quantity have been found loose in the soil near Elf Post Office, on Shooting Creek, Clay County. It has also been found in more or less quantity as fine grains and crystals in the concentrates obtained from monazite mining.

In South Carolina the principal occurrence of rutile is in the monazite sands.

In Georgia rutile of gem variety occurs at Grave's Mountain, Lincoln County, and is one of the most noted rutile localities of the country on account of the beautiful specimens of this mineral it has produced.

The rutile of Arkansas has been known for a great many years and is of scientific interest. The principal locality being near Magnet Cove.

CORUNDUM

The Southern States were formerly the producers of all the corundum (with the exception of the emery variety) that was used in the United States. The first deposits of corundum (not including the emery variety) to be mined in the world were in North Carolina,[7] in 1871, followed in 1872, by the opening of the mines in Georgia.[8] The two mines that have made the South famous for its corundum are the Corundum Hill Mine, at Cullasaja, Macon County, North Carolina, and the Laurel Creek Mine, at Pine Mountain, Rabun County, Georgia. The corundum from the latter mine is still known as standard corundum,

[7] North Carolina Geological Survey, Vol. 1, p. 361, 1905. (Pratt and Lewis).
[8] Ibid. p. 361, and Georgia Geological Survey, Bulletin 2, p. 77, 1894. (King).

and is considered the best corundum ever put on the market. There has been no production of corundum from the Southern States since 1904. The credit for the development of the corundum mined in North Carolina and Georgia, which resulted in the building up of the corundum industry in this country is due principally to Col. C. W. Jenks and Dr. H. S. Lucas, the former having begun the work at the Corundum Hill Mine in 1871.

There are many interesting occurrences of corundum in the South and at the present time it is known to occur in the following rocks:

Igneous	Peridotite Pyroxnite Amphibolite Anorthosite	Granite Pegmatite
Metamorphic	Serpentine Gneiss Mica-schist	Quartz-schist Amphibole-schist Chlorite-schist
Alluvial	Gravel deposits	
Undetermined	Emery	

The principal commercial deposits of corundum were associated with the peridotite rocks and other closely allied basic magnesian rocks, which form a narrow belt extending from Tallapoosa County, in east central Alabama, into the Gaspe Peninsula on the Gulf of St. Lawrence, a distance of more than 1,600 miles.

Corundum in Peridotite:—Throughout nearly the entire southern portion of the belt, in North Carolina, Georgia, and Alabama, the peridotite rocks show a freshness almost to the surface of the exposures, and there are few localities where there is any considerable area of peridotite entirely altered to serpentine. Under the microscope thin sections of the dunite show an alteration to serpentine between the particles of olivine.

The peridotites and associated basic rocks occur as oval, lenticular, and irregular masses and sheets in a region of metamorphic rocks composed chiefly of biotite-gneiss. As subordinate facies of this normal gneiss, however, more or less extensive

areas of hornblende-gneiss, mica-schist, and quartz-schist are developed. Peridotites are found inclosed by or in contact with all of these various types. On account of greater resistance to weathering it often happens that hornblende-gneiss is most conspicuous in outcrops, even where relatively unimportant in extent. Hence it has often been reported that the peridotites are always, or at least in most cases, associated with hornblende-schist.

The corundum found in these peridotites does not occur as accessory mineral or a rock constituent, but is concentrated either near the contact of the peridotite and the inclosing gneissic rocks or in pockets within the mass of the peridotite. A series of secondary minerals, however, has been developed both along the contacts and with the corundum masses within the peridotite, so that the corundum is not found in direct contact with either the peridotite or the gneiss, nor are these rocks in contact with each other. The secondary minerals are chiefly chlorites, vermiculites, enstatite, and talc, and are not in any sense the results of contact metamorphism. It is customary to refer to these corundum-bearing zones as "veins," and that term is used here merely for convenience, without implying any particular character or origin. Those occurrences about the borders of the peridotites are designated as "border veins," and those wholly within the peridotite as "interior veins." Corundum has been found in such deposits in North Carolina, Georgia, and Alabama.

At all of the corundum localities examined a careful search has been made to find corundum directly surrounded by the peridotite, but this has been observed at only one locality—the Egypt Mine, on the western slope of Sampson Mountain, in Yancey County, N. C. The few specimens obtained were collected by Mr. U. S. Hayes, who developed the corundum property in that section. One specimen shows a prismatic crystal of the corundum surrounded by a granular peridotite (dunite), but with none of the chlorite minerals which usually intervene. The dunite is not quite fresh, but is stained a yellowish brown by iron oxide and is rather friable. On the basal surfaces of the

corundum a little muscovite is developed. This has been observed on corundum from other localities.

Corundum in Pyroxenite:—At many of the corundum-bearing peridotite localities in North Carolina, such as those of Macon, Jackson, and Transylvania counties, a pyroxenite composed of interlocking, coarse-bladed, gray enstatite constitutes an important part of the outcrop; and at a number of places the pyroxenite alone forms oval and lenticular masses in every way similar to those composed of peridotite. In both cases corundum-bearing zones of secondary minerals are frequently formed along the borders of the pyroxenite and intersect the mass of the rock in exactly the same manner as described above for peridotite. Enstatite rocks are somewhat common in North Carolina, but accessory minerals in them are rare, and the most common one observed is chromite, in small grains. In a few instances corundum has been found in them.

Corundum in Amphibolite:—Associated with the peridotite rocks of Clay County, N. C., and of the adjoining Towns County, Ga., are dikes of amphibolite, which are for the most part between the peridotite and the gneiss, although in some places they cut the peridotite formation close to the contact of that rock with the gneiss. These dikes vary in width from 25 to over 300 feet, their average width being from 75 to 100 feet.

Corundum in Anorthosite:—The amphibole, with its prevailing light-green amphibole and small amount of feldspar, that so frequently accompanies and intersects the peridotites of Clay County, N. C., and of Towns County, Ga., becomes in places highly feldspathic, and by the dwindling and disappearance of the amphibole it passes into the anorthosite facies at several localities.

Anorthosites of this character, with more or less corundum in grains and irregular masses distributed through the rock, are found on the western slopes of Chunky Gal Mountain, Clay County, N. C., and in association with some of the amphibolites of the Buck Creek area in the same county. These rocks are always greatly subordinate in quantity to the associated amphi-

bolites and peridotites, and never constitute more than an insignificant part of the outcrops.

Corundum in Pegmatite:—Occurrences of corundum in pegmatite are extremely rare, but it has been found in this rock in two localities in Haywood County, North Carolina. One is at Retreat, on Pigeon River, 6 miles southeast of Waynesville, where corundum occurs in small pegmatite dikes, cutting the saprolitic, garnetiferous gneisses or schists. Accompanying these dikes are thin seams of vermiculites that also carry corundum. The other locality is three miles northeast of Canton, at the Presley mine, where corundum occurs in a pegmatite which intersects a mass of dark-green amphibolite. The corundum is found surrounded by both feldspar and mica.

Corundum in Serpentine:—At a number of peridotite localities in North Carolina and Georgia crystals and fragments of corundum have been found that were surrounded by serpentine, but nowhere in the Southern Appalachian region has corundum been found associated with the larger masses of serpentine that have been derived from the alteration of the peridotites, as at several localities in Buncombe County, North Carolina.

Corundum in Gneiss:—Corundum is found in North Carolina in the ordinary gneiss of the same belt of crystalline rocks in which the peridotites occur. It is also found in garnetiferous gneiss in Clay County, North Carolina. In several other places in Clay County attempts have been made to mine corundum that occurred in the hornblende gneiss.

Corundum in Mica-Schist:—Corundum in mica-schist has been observed at a number of widely separate localities in Virginia, North Carolina, and South Carolina; but in none of them has corundum been found in large quantities.

Corundum in Quartz-Schist: — It has recently been observed that portions or bands of the crystalline rocks of the southeastern part of Clay County, North Carolina, and the northeastern part of Towns County, Georgia, are corundum bearing. These rocks vary in composition from those that are a normal gneiss to those that contain no feldspar and can best be described as quartz-schist composed of quartz and biotite mica.

Some portions of the rock are rich in garnet, others are almost entirely free from this mineral, and occasionally there are also small bands of white quartzite.

Corundum in Amphibole-Schist:—At the Sheffield mine, in Cowee Township, Macon County, North Carolina, corundum has been found in a saprolitic rock which is apparently altered amphibole-schist, which was originally a rock belonging to the gabbroid family.

The corundum does not occur in crystals, but in small fragments and in elongated nodules, which are cracked and seamed and appear to have been drawn out by the shearing processes. The general character and shape of the fragments of corundum would indicate that they were original constituents of the igneous rock and were not formed during its metamorphism.

Corundum in Chlorite-Schist:—Besides being associated with chlorites in the peridotites and pyroxenites, already mentioned, corundum is found in the long belts of chlorite-schist that traverse the country 10 or 12 miles southeast of Webster, Jackson County, North Carolina. These chlorite rocks, which sometimes attain a width of several hundred feet, are traceable for miles across the country. Almost the only constituent of these rocks is a green, scaly chlorite, though sometimes there are present small grains of feldspar, and occasionally needles of amphibole. The chlorite is in small scales, never very coarse, as is sometimes the case in the zones about the peridotite, and often these scales are so minute as to give the rock a very compact appearance.

The best corundum for abrasive purposes that was ever found was obtained from the Great Laurel Creek mine, Rabun County, Georgia. This corundum will bring the highest price on the market, and there was and always has been a demand for this variety of corundum.

CHROMITE[9]

With the exception of alluvial deposits, chromite has been found only in the peridotites and allied igeneous basic magnesian

[9] United States Geological Survey, Mineral Resources, 1901, pp. 841-948. *Ibid.* North Carolina Geological Survey, Vol. I, 1905, pp. 369-384.

rocks, or in the serpentines which have resulted from the alteration of these rocks. In the North Carolina peridotites, chromite occurs more commonly in grains or crystals, and also in embedded masses, near the boundary of the lenticular bodies of these rocks.

The mineral does not occur in well-defined veins, but is often in masses or pockets which apparently have no relation whatever to one another.

But few authors writing upon the occurrence of chromite have described the relation of the chromite deposit to the rocks in which it is found. One or two have mentioned the chromite as being found near the eastern boundary or at the northern border of the serpentine belt; but in no case has the writer been able to find any definite description. The large deposits of chromite in North Carolina occur in the peridotite rock, and near the contact of this rock with the inclosing gneiss; and where there is but a small amount of the chromite, either in pockets or in grains or crystals, these are more abundant near the contact and diminish in number toward the center of the mass of peridotite.

Mention has been made above of deposits of corundum that occur in peridotite rocks, but where we find these large deposits there is a scarcity of chromite, and where the larger deposits of chromite occur there has been little or no corundum found.

Crystallized chromite has been found only in small, isolated crystals scattered through the peridotite, or where these crystals have been concentrated in alluvial deposits. The masses of chromite show little or no crystalline structure.

The constant occurrence of the chromite in rounded masses of varying proportions near the contact of the peridotite, with the gneiss, and its occurrence in the fresh as well as the altered peridotite indicate that the chromite has been held in solution in the molten mass of the peridotite when it was intruded into the country rock, and that it separated out among the first minerals as this mass began to cool.

The peridotite (dunite) magma, holding in solution the chemical elements of the different minerals, would be like a saturated liquid, and as it began to cool the minerals would

separate or crystallize out, not according to their fusibility but their solubility in the molten magma. The more basic portions being, according to the general law of cooling and crystallizing magmas, the less soluble would be the first to separate out. These would be the oxides containing no silica; in the present case the chromite, spinel, and corundum. These minerals would solidify or crystallize out where the molten magma first began to cool, which would be at the contact of the mass with the country rock; convection currents would tend to bring new supplies of material to the outer boundary, which would deposit its chromic oxide as chromite.

The more fluid a molten mass of rock becomes the more favorable will be the movements and other conditions in this molten mass to the bringing about of these changes, and it is in these very basic magnesian rocks that we find the best illustrations of the separation and concentration of the more basic minerals.

This would account for all the irregularities of the chromite deposits—their pockety nature, the shooting off of apophyses from the main masses of the chromite into the peridotite, the widening and pinching of the chromite "lodes," and the apparent non-relation or non-connection of one pocket of chromite with another. There has not been sufficient work done in the North Carolina chrome mines to demonstrate exactly the position and relation of the chromite deposits to the gneiss or other country rock, and in the description of other chrome mines but little light has been thrown on this point. The chromite would be concentrated near the borders of the peridotite in rounded masses, with offshoots penetrating into the peridotite. The lines of contact near the gneiss would be sharp and nearly regular, while with the peridotite the contact would be very irregular. The pockets of chromite found in the midst of a peridotite formation, which at the present time are isolated and have no connection with each other, were at the time of their formation part of the chromite concentrated near the border of the peridotite, but the rapid erosion to which the rocks has been subjected has worn them down to their present

condition. Again, there would be a somewhat gradual passage from the chromite to the pure peridotite.

In prospecting for either chromite or corundum the largest and richest deposits may be expected near the contact of the peridotite with the gneiss or other country rock.

Chromite has been found only in peridotite and serpentine, and the presence of this mineral in these rocks would at once indicate that the rocks were of igneous origin.

The large deposits of chromite in the serpentine rocks of Pennsylvania and Maryland show that the primary rock was of igneous origin and that the mineral solidified out from the molten magma, as described above.

A natural corollary to be drawn from this proposition is that the occurrence of chromite in an alluvial deposit indicates the proximity of a peridotite rock of igneous origin, which was the original source of the chromite.

The association of platinum with chromite and serpentine, in various parts of the world where platinum has been found in alluvial deposits, indicates that the origin of the platinum is a peridotite or allied rock of igneous origin. On the eastern slope of the Urals platinum has been found associated with chromite, which is disseminated through an olivine rock. It is not unreasonable to suppose that platinum would be found in the peridotite areas of the Southern States.

The mining of chromite in this country has always been attended with considerable uncertainty on account of the pockety nature of the deposits, and for this reason chromite properties are more apt to be leased than bought outright. Usually no estimate can be made regarding the amount of chromite on a property beyond that which is exposed by the actual work done. Yet, considering the theory advanced for the origin of chromite, if a deposit of this mineral is found near the contact of the peridotite and other country rocks, and if this peridotite formation is very extensive and the chromite is found in considerable quantity, there is good probability that it will develop into a large deposit.

Maryland was one of the first states in which chromite was

discovered and mined in this country. The first chromite found was in 1827 on the Reed farm in Harford County, about 27 miles northeast from Baltimore. There has been no mining of chromite in Maryland for twenty years.

The only other Southern State that offers any probability of being a producer of chromite is North Carolina. Extending from Ashe County to Clay County, North Carolina, there is a series of disconnected peridotite outcrops; and, as has been observed above, chromite is associated with all these peridotite rocks. It is, however, in few localities only that the mineral has been found in considerable quantity. Although prospecting for chrome ore in this State was first undertaken over thirty years ago and has been continued spasmodically ever since, there has never been any systematic development of the localities.

In the alluvial deposits at the base of the peridotite outcrops there is usually a considerable amount of chromite crystals and particles, but nowhere have they been observed in sufficient quantity to constitute a chrome sand ore.

The general character of the chromite ore is nearly uniform throughout the entire area, being very hard and compact, though often of a fine granular appearance, and there is but little that is at all friable. The masses of chromite are usually very free from seams of peridotite or its alteration product. This simplifies the concentration, and a high grade ore can usually be obtained by cobbing and hand picking.

The more important deposits of chromite in North Carolina are in Yancey and Jackson counties, and in the former the deposits occur at Mine Hill, about five miles north of Burnsville and within a few miles of the Clinchfield Railroad. The deposits of Jackson County are near Webster and a few miles southwest of Balsam Gap on Dark Ridge Creek. These deposits are on the Southern Railway.

As yet the existence of large deposits of chromite in North Carolina has not been conclusively shown, but the work done points to the possibility of large deposits in that State, those described above being the most promising ones known.

The standard chrome ore contains 50 per cent of Cr_2O_3, and

the value of the ore increases with each unit over this. Ores as low as 45 per cent Cr_2O_3 find a ready market if they are low in silica. The North Carolina ores are high grade and usually low in silica.

CHAPEL HILL, N. C.

(*Continued in next issue*)

GEOLOGY OF CHAPEL HILL AND VICINITY

An Outline

BY JOHN E. SMITH

The circular area having a radius of about five miles with Chapel Hill near its center is located chiefly on the eastern margin of the Piedmont Belt, but includes a small portion of the arm of the Coastal Plain that extends northward beyond Oxford and whose western border is less than two miles east of the village.

TOPOGRAPHY

The area is traversed by New Hope Creek in its northern part, by Bolin's Creek near the middle, and by Morgan's Creek on the south. Its drainage is therefore excellent. These streams flow eastward to the plain where they join and flow southward until they reach the waters of the Cape Fear. The general elevation of the upland is 500 to 540 feet and that of the creek bottoms and the plain is about 200 to 250 feet lower. This gives the area the rugged topography typical of the eastern margin of the Piedmont Plateau.

Into this plateau the streams have cut their valleys by erosion; this work is still in progress and can be observed in every stage of advancement in each of the larger streams of the area, from the smallest gulley to the broad mature valley. The small deep, steep sided valleys show youthful stages of development. As one proceeds down stream, a point is reached where the current is checked to such an extent that the cutting is confined to one level; here the valley begins to grow in width, a floodplain forms, and from this place down the valley, the various stages of maturity, increasing in age with the distance, are illustrated. This side cutting or lateral planation proceeds very slowly on the outer curve of a meander where it touches the valley wall, and in time, by crossing from one valley wall to the other, develops a broad floodplain. The region as a whole is one of ma-

ture topography because its surface lies chiefly in slopes with but little reduction of the summit level of the divides.

There are a few hills rising from the Coastal Plain near its margin almost to the elevation of the upland plateau and on this plateau several hills reach an elevation of 100 to 200 feet above it. Among these are Nunn's Mountain, Blackwood Mountain, Mount Collier, and others.

CYCLES OF EROSION

Before the streams began to cut the valleys now forming, the plateau was nearly continuous and unbroken save for a few hills, that at Hillsboro for example, rising from it. As the present stream work proceeds, the floodplains gradually work headward along the streams thus developing a longer and broader plain at the new level. On this floodplain, though sometimes covered, are sand, gravel, and waterworn rocks brought by the current during freshets or left when migrations of the channel occurred. When the new level cut by each stream meets, in places, that formed by the other streams, the result is a very broad plain with hills rising from it. These hills are called monadnocks and the level formed is a peneplain. A base level is completed when all of the monadnocks have been removed by erosion.

The changes made in the young valleys can be observed after each hard shower or from year to year. A lifetime, however, reveals very little if any increase in width of the mature valleys by lateral planation. The period between the time when the streams begin to erode the upper plain, and the completion of the one at the lower level, constitutes a cycle of erosion. The duration of such a period is very, very great and a cycle of erosion is one of the longest definite intervals of geologic time.

Numerous specimens of waterworn (smooth and rounded) pebbles of quartz and its varieties up to four inches in diameter have been collected by the writer and others from various places on the upland and hill tops both east and west of Chapel Hill. These can be none other than the surviving ones from the gravels of a river floodplain as it was being developed at the

temporary base level of that time. Similarly rounded smooth pebbles in similar positions are found throughout the Piedmont Belt. Also the folded layers of stratified and metamorphic rocks of this region are truncated at the elevation of the upland. The plateau level of the area about Chapel Hill and elsewhere in the Piedmont is therefore a peneplain.

On this peneplain several monadnocks occur, the hill at Hillsboro for example, also numerous hills of igneous origin that are in all probability monadnocks. Among these are Nunn's Mountain and Blackwood Mountain, each about five miles north of Chapel Hill, and Mount Collier[1] about the same distance to the west.

Two cycles of erosion are therefore evident in this vicinity, one nearly completed, during which the peneplain was formed, the other now in progress, during which the valleys are being excavated and the new temporary base level developed. When the Piedmont as a whole is considered, strong evidence of earlier cycles of erosion is found.

ARCHEOZOIC ERA

The rocks of this system consist of gneisses, schists, slates, etc., with granites and other igneous rocks intruded into them. The metamorphic rocks are complexly folded and have been truncated by erosion. All are disintegrated to a depth of 20 to 50 feet. They occur throughout the vicinity except in a circular area near its center and are closely related in age with the oldest rocks of the American continent.[2]

PROTEROZOIC ERA

The rocks of this system are conglomerates, both basal and intraformational, sandstone, porcellanite, slates, schist, etc., interstratified with numerous acidic lava flows, chiefly trachytes and rhyolites. The outcrops are along the right (south) valley slope of Morgan's Creek, and are best exposed at the old site of

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[1] Mount Collier is so called in honor of Professor Collier Cobb, Head of the Department of Geology in the University of North Carolina, who in 1892 was the first to recognize its volcanic origin.

[2] Pre-Cambrian Geology of North America, 1909, Van Hise and Leith, Bul. 360, U. S. Geol. Survey, p. 677 ff. and 695 ff. Gives a summary of Pre-Cambrian Geology of North Carolina and lists references for the State.

Purefoy's mill about two miles south of Chapel Hill. An outcrop occurs also at McCauley's Quarry about seven miles to the west.

Before the close of the era, great intrusions and uplifts occurred tilting the stratified rocks to an angle of 65 degrees. The Chapel Hill stock may have had its origin at this time. It consists chiefly of granitoid rocks,[3] (granites,[4] etc.) but is believed to be in part composed of basic igneous rocks derived by magmatic segregation. It is cut by numerous dikes, both acidic and basic, ranging from granitoid to felsitic textures. The dikes occupy the joint planes which extend approximately N. 30 E. and N. 60 W.

PALEOZOIC ERA

That this region was an area of high land during the earlier part of this era, is shown by the great volumes of sediment derived from it. These are the sedimentary rocks of western North Carolina, eastern Tennessee and Kentucky and have a total thickness of nearly 20,000 feet. This continent, known as Appalachia, sloped to the west or northwest and probably extended eastward into the area now covered by the Atlantic Ocean. The Paleozoic seas covered most of what is now the Mississippi Valley and extended east to the present position of the Blue Ridge Mountains or farther.[5]

Near the close of the era, great stresses produced the Appalachian Mountains by very slow folding which also affected our area causing a relative uplift in western North Carolina. This changed the slope of the land and our streams flowed eastward or northeastward over a lower area.

MESOZOIC ERA

After the tilting of the surface and the erosion that followed, an incursion of the sea came from the northeast. During this

[3] Eaton, H. N., Notes on the Petrography of the Granites of Chapel Hill, N. C. Jour. E. Mitchell Sci. Soc. 25:85. 1909. Also, Flint-Like Slate near Chapel Hill, N. C., *ibid* 24, 1908.

[4] Fry, W. H., Some Plutonic Rocks of Chapel Hill. Jour. E. Mitchell Sci. Soc., 27: 124. 1911.

[5] Pratt, Dr. J. H., Geology of Western N. C. Jour. E. Mitchell Sci. Soc., 29: 35. 1913.

time the location of the present site of Chapel Hill with respect to the sea was somewhat like that of Annapolis, Md. This long, narrow body of water extended northward into New England and is known as the Triassic sea. The rocks formed by disposition in it and near it are conglomerates, sandstone, quartzite, arkose (contains orthoclase and muscovite). They occur on the plain, also as outliers resting unconformably on the flank of the eroded granite of the stock.

The sea was a shallow one as it receded. This is shown by the fossil deltas, sand dunes, mud cracks, etc., left above the deeper water deposits. Arms of the sea were cut off as it withdrew, and evaporation left among the sediments, its salts, which give salinity to the water of the wells and springs of this part of the area. The swamps of these low areas were the feeding places of very large lizard-like animals whose tracks and fossil remains are found in these beds. These rocks carry also the petrified forest of North Carolina, part of which is about two miles east of Chapel Hill.

Near the end of the Triassic period, its rocks were folded[6] and faulted and some intrusions of igneous dikes, sheets, etc., probably occurred. A very long interval of erosion took place before the close of the era and the elevation again became low.

CENOZOIC ERA

Several changes in elevation occurred during this era as the sea twice advanced from the east nearly as far as the present site of Raleigh. The most striking thing in the geological history of this vicinity is the fact that most of it has remained a land area almost continuously since Pre-Cambrian times. As a result of this very long interval of weathering and erosion the bedrock is covered by a residual mantle rock described in the following:

GENERALIZED SECTION

1. Soil, "Top soil," red to gray and black (humus),............1 to 2 ft.
2. Subsoil, fine, red to yellow clay..............................3 to 10 ft.
3. Clay, coarse, lumpy, some sand..............................5 to 20 ft.

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[6] Miss Florence Bascom, Historical Geology of the Piedmont Area. U. S. Geol. Survey, Trenton, N. J. Folio No. 167, p. 19.

4. "Gravel," "Natural Sand-Clay," fragments of orthoclase and quartz with sand and clay..............................10 to 20 ft.
5. Fragmental rock, partly decomposed angular fragments 2 to 4 inches in diameter..................................10 to 15 ft.
6. Fragmental rock, angular, much coarser and less decayed than in No. 5.....................................5 to 15 ft.
7. Solid rock, "Bedrock," "Country rock."

THE PROBLEM OF ZONATION

That some zonation exists in the igneous rocks of this vicinity has been shown by Professor Collier Cobb.[7] This problem, however, has not been fully solved and there are several factors which make its complete solution extremely difficult.

The mantle rock in this area is twenty to fifty feet thick which prevents the occurrence of many exposures of the solid rock. This makes it very difficult to determine accurately the relations and boundaries of the probable zones beneath. If wide dikes of various igneous rocks, deeply covered, cross each other nearly at right angles, the result would closely simulate zonation in which the zones are somewhat circular. Such a resemblance would be especially strong in this vicinity where half or more of the zone circle is concealed beneath sedimentary and metamorphic rocks. These conditions, however, do not disprove the presence of zonation; they have not been fully confirmed by observation in the field but are suggested by the occurrence of acidic and basic dikes throughout the stock.

ECONOMIC GEOLOGY

Zone No. 1 of the generalized section given above is the true surface soil of the upland and No. 2 contains the brick clay of the area. Some of the clay used in the old brickyards of Chapel Hill was taken from zone 3 and therefore unsatisfactory results were obtained. Zones 1 and 2 have been largely removed by the long continued erosion and neither now occurs in very large areas in the vicinity.

This leaves zone 3 at the surface over a large part of the area, especially on the valley slopes, and No. 4 and its decomposition

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[7] Zonation in the Chapel Hill Stock. An address (unpublished) before the Elisha Mitchell Scientific Society, December, 1912.

products at the surface on the lower part of the slopes. These produce sandy or gravelly soils that are, as a rule, inferior in quality. They respond readily, however, to the influences of modern methods in agriculture: crop rotations, diversified farming, the growing of fertilizing crops, etc.

The rugged topography with its east-west valleys and divides retards the development of railway transportation, thus depriving the area of ready access to market. This, with the above mentioned factors, accounts for the low value of land in a tier of counties[8] along the eastern margin of the Piedmont Belt from Granville and Person to Montgomery and Moore inclusive, Orange being one of the number.[9]

Zone 4 of the generalized section provides a natural sand-clay suitable for use in road building.[10] The material used on Franklin Street was taken from a pit opened in this zone, the upper part of this zone should not be used without the addition of stream sand. Numerous other places in this area would yield material of the same quality. The stream sand is used also in making mortar, etc.

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[8] North Carolina Supplement, Tirteenth Census Report.

[9] Holmes, J. S., Timber Resources of Orange County, N. C. Jour. E. Mitchell Sci. Soc. 39:89, 1914.

[10] Smith, John E., Natural Sand-Clay in the Piedmont, *Southern Good Roads*, current number.

A STUDY OF THE ACTION OF VARIOUS DIURETICS IN URANIUM NEPHRITIS, WITH SPECIAL REFERENCE TO THE PART PLAYED BY THE ANESTHETIC IN DETERMINING THE EFFICIENCY OF THE DIURETIC[1]

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In a previous number of this journal (1), a report was made on the action of various diuretic substances in animals rendered nephritic by uranium nitrate. The animals employed in this series of experiments could be classified, on a basis of their re-

[1] Presented in abstract before the Society for Pharmacology and Experimental Therapeutics, Cleveland, December 30, 1912. Aided by a grant from the fund for Scientific Research of the American Medical Association.

[2] Reprinted from The Journal of Pharmacology and Experimental Therapeutics, Vol. IV, No. 6, July, 1913.

sponse to diuretics, into three groups: an anuric, a practically anuric, and a diuretic group.

In the present invesitgation, which is a direct continuation of the previously mentioned experiments, the same general grouping of the animals can be established. It has been experimentally demonstrated, however, that the practically anuric group is an unnnecessary refinement in the classification, for the condition of partial anuria should be interpreted as a forerunner of the anuric state which sooner or later develops, provided the experiment be continued. Therefore, in the present report the observations will be confined to two groups of nephritic animals: a diuretic group and an anuric group.

The present investigation shows, also, that whether or not the animals are diuretic or anuric following the anesthetic depends very largely upon the anesthetic employed and upon the age of the animals. As a result of this observation, in addition to a continuation of the study of the response of the pathological kidney to diuretics, it becomes especially necessary to consider the response of the pathological kidney to different anesthetics.

REVIEW OF PREVIOUS EXPERIMENTS

In the experimental work previously published it was shown that when dogs were given uranium nitrate subcutaneously in the dose of from 5 to 10 mgs. the animals developed an albuminuria, which was followed within twelve to forty-eight hours by a glycosuria. The output of sugar in the twenty-four hour specimen of urine varied within wide limits: 0.25 to 3.22 per cent. No determination of acetone or acetone bodies was made.

It was also shown that either just prior to the development of the alubuminuria, or associated with its development the output of urine increased, and that with the development of the glycosuria the animal became highly polyuric. For instance, in experiment 8, of the previously mentioned series the animal was receiving 500 cc. of water daily; the average output of urine prior to the uranium was 513 cc.; while following the uranium and with the development of a nephritis and a glycosuria the urine increased to 1310 cc.

The microscopic examination of the urine constantly showed the presence of erythrocytes, usually few in number, and tube casts. Early in the nephritis, with the first appearance of albumin, the hyaline cast predominated, but later when the alubuminuria had become more marked, granular casts predominated over the hyaline type.

When such animals which were nephritic, glycosuric, and polyuric were anesthetized by either Gréhant's anesthetic or by morphine-ether, they grouped themselves, so far as their response to diuretics was concerned, into two mains groups: an anuric group and a diuretic group.

The physiological study of these two types of animals with special reference to their response to diuretics, showed, in the first place, that no change had been induced in the height of general blood pressure to account for the difference in the output of urine in the two groups. Secondly, oncometric determinations of the local renal circulation showed that the response of the renal vessels in both groups was either normal or hyperactive. This was true for substances such as caffeine and theobromine which are supposed to influence the renal circulation principally through a local vascular effect, as well as for such a substance as digitalin, whose local effect on the blood supply of the kidney is induced through its general effect upon the circulation.

As a result of the above mentioned study of the general and local vascular response of the nephritic animals, the cause of the stoppage of the urine flow in the anuric group was thought not to be due to any vascular change.

The histological study of the kidneys from the diuretic and from the anuric groups showed a marked difference in the degree of epithelial involvement, whereas the vascular pathology in the two groups was practically identical.

In those animals that remained diuretic following the anesthetic, the epithelial involvement was slight or absent. The cells were not only not increased in size, but frequently they showed an undoubted shrinkage with an associated increase in the size of the lumen of the tubules. The cells stained well, the nucleus

was not pyknotic, and the cytoplasm of the cells showed but slight or no vacuolation.

On the other hand, in those animals which became anuric following the anesthetic the epithelium of the tubules of the labyrinth, and especially of the proximal convoluted tubules, showed an acute swelling, which was remarkable for the rapidity with which it developed. As a result of the swelling, the lumen of the tubules was either greatly encroached upon or completely occluded. In some animals the swelling was so acute that the cells had not had time to undergo any marked degenerative change, while in other animals the epithelium was severely vacuolated, staining was imperfect, the nuclei pyknotic, and the cytoplasm in various stages of necrosis.

As a result of these observations, I was inclined to the belief that in a uranium nephritis the epithelial changes were more responsible for the reduction in the output of urine than were the vascular changes.

The continuation of these experiments, which will now be reported, serves in great measure to confirm this belief, and also brings into consideration the part played by different anesthetics and by the age of the animals in precipitating these epithelial changes.

DISCUSSION OF THE TECHNIQUE EMPLOYED IN THE EXPERIMENTS

The operative technique employed in the following experiments has been identical in every particular with that employed in the experiments of the previous investigation. There have, however, been made, for the sake of accuracy, slight changes in the quantity of the nephrotoxic substance employed; and also additional diuretic fluids have been used. In place of giving from 5 to 10 mgs. of uranium nitrate to the animals without regard to their weight, there was a determination made of the dose of uranium which was competent to induce a nephritis and a glycosuria without rendering the animals in the least toxic and without inducing gastro-enteric changes, which are usually manifested by vomiting and a diarrhoea.

The dose of uranium nitrate when given subcutaneously in

the dog which is sufficient to induce the desired changes in the kidney without the undesirable gastro-intestinal complications has been found to be 6.7 mgs. per kilogram. This is the dose of uranium which has been constantly employed in all of the experiments.

Only animals in apparently perfect health were selected for the experiments. They were placed in metabolism cages and given daily by a stomach tube a known and constant quantity of water. The diet consisted of bread and uncooked meat.

The urine was collected at 4.30 p. m. each day and examined qualitatively for albumen, sugar and acetone, and quantitatively for sugar. In making both the qualitative and quantitative sugar determinations, Benedict's (2) reagents were uniformly employed, for the reason that these solutions allow of more delicate determinations and do not deteriorate upon standing. No preservative was used in the urine.

These observations were made for three days prior to the administration of the uranium. On the third day the first uranium injection was made and repeated at the same time on the fourth day, the experiment being performed on the fifth day that the animal had been under observation. Such a routine is necessary, for the changes in the urine, especially the output of glucose, are influenced to some extent by the time which has elapsed following the uranium injections.

As a result of the foregoing study of the urine the use of an animal with a naturally acquired nephritis was excluded. None of the animals prior to the use of the uranium showed the presence in the urine of either glucose or acetone.

The diuretic substances which have been employed in these experiments include those which were used with the first series of animals; and, in addition, various salts which were used in solutions isotonic with 0.9 per cent and 2 per cent sodium chloride.

The osmotic pressure of some of the salts which have been employed has never been accurately measure. This, therefore, introduces an element of error into the calculations, which were conducted in order to obtain solutions of these salts isotonic

with 0.9 per cent and 2 per cent sodium chloride. The calculations were made for solutions at 37.5°C. and at this temperature the solutions were introduced into the animals. For these calculations, I am indebted to Dr. J. E. Mills, of the University of South Carolina.

The following solutions have been employed in the study of the response of the nephritic kidney to diuretic substances:

Caffeine	1 to 2 of a 1 per cent soution per kilogram
Theobromine	1 to 2 of a 1 per cent solution per kilogram
Digitalin	0.5 to 1mg. per kilogram
Sodium chloride solution, 0.9 per cent	5 to 10 cc. per kilogram
Sodium chloride solution, 2 per cent	5 to 10 cc. per kilogram
Sodium carbonate, 0.9 per cent	5 to 10 cc. per kilogram
Sodium carbonate, 2 per cent	5 to 10 cc. per kilogram
Sodium sulphate, 0.9 per cent	5 to 10 cc. per kilogram
Lithium chloride, 0.9 per cent	5 to 10 cc. per kilogram

THE EFFECT OF URANIUM NITRATE ON THE OUTPUT AND COMPOSITION OF THE URINE IN YOUNG AND IN FULL GROWN ANIMALS

As has been previously stated, the present series of experiments serve not only for a study of the efficiency of various diuretic substances, but they also serve to demonstrate the difference in the response of animals of different ages to the same quantity of a toxic substance, such as uranium. The differences here referred to are those which are manifested in the total output of urine and in the composition of the urine.

During the course of this paper the animals referred to as "young," are animals not over one and a half years old; the "adult" animals are those varying in age between one and a half and six years; while the old animals are certainly over six years old. The classification is, of course, a more or less arbitrary one, though it is based to some extent upon a knowledge of the average life of the dog.

Falling in the group of young animals are eight dogs. Four of these animals were from the same litter, and at the time of the experiments were between four and a half and five months old. Two other animals were three months and three weeks old;

while the remaining two dogs, young adults, as accurately as could be ascertained, were about one year and two months old.

The animals were given daily a known and constant quantity of water and allowed a mixed diet of bread and raw meat. Following the preliminary period of observation of three days, they were given subcutaneously on two successive days 6.7 mgs. of uranium nitrate per kilogram. The two young adult animals received 500 cc. of water daily, while the other members of the group received 400 cc.

On the second day of the uranium injections these animals showed the following changes in output and in composition of the urine:

As will be seen from table 1, these animals, following the development of a glycosuria, became polyuric. The output of glucose, especially by the puppies, is remarkably constant for the different animals, while the presence of acetone varies. The

TABLE I

Age	Water cc.	Urine cc.	Albumen	Sugar per cent	acetone
Young adult	500	830	Present	1.06	Trace
Young adult	500	1015	Present	0.701	Trace
Puppy	400	790	Present	0.202	None
Puppy	400	780	Present	0.446	None
Puppy	400	740	Present	0.077	None
Puppy	400	605	Present	0.35	Trace
Puppy	400	910	Present	0.434	Trace
Puppy	400	910	Present	0.86	Trace

quantity of acetone in the urine of these young animals is exceedingly small and its detection would frequently have been missed without a microscopic examination of the tested distillate for the presence of crystals of iodoform.

The group of animals referred to as "adult" animals were kept on the same diet as the younger animals, and like the younger animals were given 6.7 mgs. of uranium nitrate per kilogram on two successive days. The changes in the output of urine and in the composition of the urine are indicated in table 2, which represents the course of eight characteristic experiments following the uranium injections and prior to the use of an anesthetic.

TABLE II

Age	Water cc.	Urine cc.	Albumen	Sugar per cent	Acetone
Adult --	500	1240	Abundant	2.17	Pronounced
Adult --	300	645	Abundant	2.56	Pronounced
Adult --	500	980	Present	2.17	Present
Adult --	500	1180	Present	3.625	Present
Adult --	500	1025	Present	2.08	Present
Adult --	500	1515	Present	2.08	Present
Adult --	500	1130	Present	1.06	Present
Adult --	500	885	Present	3.03	Present

A comparison of the two tables showing the results obtained in these groups of animals, representing different age limits, shows in the first place, that the polyuria which, as has been previously stated, becomes pronounced with the development of the glycosuria. The animals of the adult group show a higher degree of polyuria than do the younger animals; and they also show, with one exception, a uniformly higher percentage of glucose.

Although quantitative determinations of acetone were not made, we feel reasonably certain that the acetone output in the adult animals was dictinctly in excess of that of the younger animals. Judging from the density of the precipitate of albumen the same statement may be made for this element of the urine.

The microscopic examination of the centrifugalized urines invariably showed that in the adult animals casts were far more numerous that in the young animals. The increase in the number of fatty casts was especially noticeable.

From the foregoing observations, the following deductions appear allowable:

1. Uranium nitrate when given subcutaneously in the dose of 6.7 mgs. per kilogram induces in the dog a series of changes which vary in their degree of severity.

2. The severity of these changes is determined by the age of the animal, the changes being more pronounced in adult animals and less pronounced in young animals.

3. The factors which determine these differences in the

response of animals of different ages to the same quantity of uranium are at present undetermined.

THE EFFECT OF GRÉHANT'S ANESTHETIC[3] ON THE OUTPUT AND COMPOSITION OF THE URINE IN YOUNG AND IN ADULT ANIMALS

In the experiments that have been previously reported (1) in which this anesthetic was employed, the anesthetic was used in the full strength advised by its originator. In order to exclude the possibility of the anesthetic unduly depressing the circulation, in the present experiments the quantity of the anesthetic has been reduced to 60 per cent strength. In this strength the anesthetic was given to ten adult animals and eight young animals after they had been rendered nephritic by uranium.

The ten adult animals following the development of an anesthesia which was not profound became anuric and remained anuric throughout the experiments. The anuria was uninfluenced by the various diuretic substances which have been previously enumerated.

The rapidity with which the anuria develops has varied slightly in the different animals and is apparently dependent to some extent upon the depth of the anesthesia.

The following experiments illustrate this point:

Experiment 4. The animal was receiving 500 cc. of water daily. On the day of the experiment the animal had an output of urine of 1130 cc. Within forty minutes after the commencement of the anesthetic, which resulted in a complete anesthesia, the animal became anuric. During the course of the experiment no urine was obtained. At the commencement of the experiment the animal had a blood pressure of 95 mm. of mercury, and at its termination a blood pressure of 115 mm. of mercury.

Following the injection of 1 cc. of a 1 per cent solution of caffeine per kilogram, the general blood pressure was raised from 105 to 115 mm. of mercury and the oncometer pressure as indicated by a water manometer, showed a rise of 16 mm. of water.

Experiment 7. In the following experiment the animal was imperfectly anesthetized. During the operation he was constantly struggling. On the day of the experiment the output of urine was 1025 cc. For the first

[3] Gréhant's Anesthetic: The animal is given 0.25 cc. per kilogram of a 4 per cent. solution of morphine. This is followed in half an hour by 10cc. per kilogram of the following mixture: chloroform, 50cc.; alcohol and water, each 500cc.

half hour period that the animal was under observation after the completion of the operation the output of urine was 2.7 cc. Following this period of diuresis the animal became completely anuric, and with the development of the anuria the struggling and other evidences of an imperfect anesthesia ceased. ,

At the commencement of the experiment the animal had a blood pressure of 105 mm. of mercury, and at its termination a blood pressure of 165 mm. of mercury. At no time during the experiment was there evidence of any over action of the anesthetic. The animal remained completely anuric to caffeine, theobromine, digitalin, 0.9 per cent sodium chloride and 2 per cent sodium chloride. The experiment shows that even though an adult animal may not be completely anuric at the commencement of an experiment, the changes in the kidney which are inaugurated by the anesthetic, progress with the anesthesia, and that with the development of a state of satisfactory surgical anesthesia an adult animal which has been anesthetized by Gréhant's anesthetic becomes anuric.

The young animals and puppies that had been rendered nephritic, glycosuric, and polyuric by the same quantity of uranium per kilogram that was employed for the adult animals, showed after the administration of Gréhant's anesthetic in 60 per cent strength a distinct difference in the effect of the anesthetic on the output and composition of the urine.

Although this group of young animals received the same quantity of Gréhant's anesthetic and although they were allowed the same time in which to develop the anesthesia, they were not so completely anesthetized at the expiration of this period as were the adult animals. It was usually necessary to give these animals a small quantity of ether to complete the anesthesia. After a satisfactory state of anesthesia had been established, it was rarely necessary to administer the ether again. The animals remained satisfactorily anesthetized throughout the experiment, which usually lasted several hours.

The animals of this group show a distinct difference in the effect of the anesthetic on the urine flow. None of the members of the group were rendered anuric by the anesthetic, but, on the other hand, they were distinctly diuretic before and after the introduction of various diuretic substances.

The urine of this group of diuretic animals showed after the anesthetic an increase in the quantity of glucose and in those animals in which acetone was not present in the urine

prior to the anesthetic, after the anesthetic, acetone was invariably present.

The observation that has been made relative to the increase in the quantity of glucose in the urine after the anesthetic might be questioned on the ground that the increase in glucose was a relative rather than an absolute increase, e. g., that with the animals not so diuretic after the anesthetic as they were before the fact that the urine became more concentrated would show a rise in the percentage of glucose.

To eliminate this possibility a series of normal animals were given Gréhant's anesthetic, and the changes induced in the composition of the urine were noted. (3) Following the anesthetic these animals developed a glycosuria, the percentage of glucose varying with the age of the animals. It seems therefore allowable to conclude that when Gréhant's anesthetic is given to a glycosuric animal the increase in the percentage of glucose in the urine is an absolute rather than a relative increase.

The following experiment will serve to show the difference in the output and composition of the urine in a young animal from that of the previously discussed adult animals.

Experiment 18. The animal was receiving 400 cc. of water daily. On the day of the experiment the output of urine was 780 cc. The urine contained 0.446 per cent glucose but no acetone. Following the anesthetic, the gluecose increased to 0.99 per cent and an acetonuria developed. At the completion of the operation this animal had a blood pressure of 111 mm. of mercury and a urine flow of 1.4 cc. per ten minute interval.

During the course of the experiment, which lasted for three and a a half hours, the animal was completely anesthetized and was freely diuretic to caffeine, digitalin and 0.9 per cent sodium chloride. At the termination of the experiment the animal had a blood pressure of 118 mm. of mercury and a urine flow of 4.5 per ten minute interval.

THE EFFECT OF MORPHINE-ETHER ON THE OUTPUT AND COMPOSITION OF THE URINE IN YOUNG AND ADULT ANIMALS

The young animals which received this type of anesthetic showed but slight differences in the output and composition of the urine and in their response to diuretics from the young animals receiving Gréhant's anesthetic. The following experiment shows the similarity in the response of these animals to morphine-ether.

Experiment 17. The animal was completely anesthetized. Prior to the anesthetic the animal was receiving 400 cc. of water. On the day of the experiment the animal had an output of urine of 790 cc. The urine contained 0.202 per cent of glucose and was free from acetone. Following the anesthetic the animal remained diuretic and had an output of urine of 2 cc. per ten minute interval before the use of any diuretic substance. During the course of the experiment the animal remained diuretic to caffeine and digitalin. The urine collected showed an increase in glucose to 0.501 per cent. The urine contained acetone.

The adult animals which were given morphine-ether differed from the adult animals receiving Gréhant's anesthetic in that they did not become anuric, but remained responsive to the same diuretic substances which when employed in animals anesthetized by Gréhant's anesthetic were found to have no diuretic value.

Two very old animals that were nephritic from uranium which were given morphine-ether, became anuric and the anuria was uninfluenced by caffeine, digitalin and 0.9 per cent sodium sulphate. These animals showed a pathological response on the part of the kidney which was similar to the pathology which develops in adult animals following Gréhant's anesthetic and which renders the animal anuric.

The following experiment shows the usual effect of morphine-ether as an anesthetic in adult animals:

Experiment 16. The animal was receiving 500 cc. of water daily. On the day of the experiment the output of the urine was 1015 cc. The urine contained 1.22 per cent of glucose. Acetone was present.

Following morphine-ether, which resulted in a complete anesthesia, the animal remained diuretic. During the first ten minute period, before the use of any diuretic substance, the output of urine was 3.4 cc. The animal was diuretic to both caffeine and digitalin. The urine obtained during the experiment showed an increase in glucose to 2.77 per cent.

CONCLUSIONS CONCERNING THE EFFECT OF GRÉHANT'S ANESTHETIC OF MORPHINE-ETHER UPON THE OUTPUT AND THE COMPOSITION OF THE URINE IN YOUNG AND IN ADULT DOGS NEPHRITIC FROM URANIUM

1. When given to adult animals, Gréhant's anesthetic produces a state of anuria which is uninfluenced by any of the diuretic substances that have been employed in this investigation.

2. When Gréhant's anesthetic is given to young animals, the animals remain diuretic and responsive to the various diuretic substances. The urine collected during the anesthesia shows an increase in glucose over that induced by the injections of uranium before the anesthetic.

3. Adult animals when given morphine-ether have only occasionally developed an anuria. The animals in our series which have developed this condition have been old animals. In the animals anuric from morphine-ether the changes in the kidney are similar to those found in the kidneys of the animals anuric from Gréhant's anesthetic.

In general, the adult animals anesthetized with morphine-ether remain diuretic and are responsive to the different diuretic substances. The urine shows an increase in the percentage of glucose.

4. The young animals anesthetized with morphine-ether have without exception remained freely diuretic throughout the experiments. The urine collected during the experiments has shown a slight increase in the percentage of glucose. This increase, however, is less than the increase observed in the adult animals under the influence of the same anesthetic.

5. In conclusion, the age of the animal apparently exerts some influence over the toxicity of the anesthetic as did the same factor influence the toxicity of the uranium prior to the anesthetic.

THE EFFICIENCY OF VARIOUS DIURETICS IN URANIUM NEPHRITIS IN ANIMALS ANESTHETIZED WITH GRÉHANT'S ANESTHETIC AND WITH MORPHINE-ETHER

The efficiency of various diuretics in animals anesthetized with Gréhant's anesthetic

In considering the efficiency of these different diuretic substances in animals anesthetized with Gréhant's anesthetic, the nephritic animals, so far as their response to the diuretics is concerned, are found to arrange themselves into two groups: a diuretic group which is represented by the young animals; and an anuric group which consists of adult animals which had re-

ceived the same quantity of the nephrotoxic substance per kilogram and the same amount of the anesthetic per kilogram as was received by the young animals.

In these animals the following diuretic substances were employed: caffeine, theobromine, digitalin, 0.9 per cent and 2 per cent sodium chloride, 0.9 per cent and 2 per cent sodium carbonate, 0.9 per cent sodium sulphate, and 0.9 per cent lithium chloride.

When these substances were employed in adult animals nephritic from uranium and anuric from Gréhant's anesthetic, they had no diuretic value. After having once become anuric these animals remained anuric.

The following experiments are representative of this group and demonstrate the inefficiency of substances as diuretics which in a normal animal or in a nephritic animal which has not become anuric, usually induce a distinct diuresis.

Experiment 12. On the day of the experiment this animal had an output of urine of 980 cc. Following Gréhant's anesthetic the animal became completely anuric and remained anuric throughout the experiment. Caffeine induced a rise in general blood pressure of from 125 to 140 mm. of mercury without any change in kidney blood pressure. Digitalin induced a rise in general blood pressure of from 130 to 140 mm. of mercury with a rise in kidney blood pressure of 6 mm. of water. Sodium carbonate in 2 per cent solution, given in the quantity of 10 cc. per kilogram, caused a rise in general blood pressure of 13 mm. of mercury and a rise in kidney blood pressure of 16 mm. of water. The animal received 175 cc. of salt solution.

Experiment 7. This animal during the first half hour period of observation was diuretic. Following this initial stage of diuresis the animal became completely anuric and remained anuric, uninfluenced by the diuretics.

The animal's general blood pressure varied between 105 mm. of mercury at the commencement of the experiment to 165 mm. of mercury at its termination. At the commencement of the experiment the oncometer showed a kidney pressure of 25.3 cm. of water and at the termination a pressure of 32 cm. Caffeine induced a rise in blood pressure of 32 mm. of mercury and a rise in oncometer pressure of 16 mm. of water. Digitalin increased the general blood pressure of 30 mm. of mercury, and the oncometer pressure 27 mm. of water, 0.9 per cent sodium chloride, 10 cc. per kilogram gave a rise in general blood pressure of only 5 mm. of mercury, while the oncometer showed an increase in pressure of 48 mm. of water, 2 per cent sodium chloride in the quantity of 10 cc. per kilogram

caused a rise in general blood pressure of 17 mm. of mercury and a rise in kidney blood pressure of 27 mm. of water. The animal received 248 cc. of salt solution.

With the employment of other diuretic solutions in this group of anuric animals, such for instance as sodium sulphate and lithium chloride in 0.9 per cent solution, the same type of response was obtained in general blood pressure changes and in the local vascular changes in the kidney as were obtained from the salt solutions just described. Neither the type of salt nor the difference in the tonicity of the solutions which were employed induced any diuretic effect.

The following series of animals which did not became anuric from Gréhant's anesthetic were young animals. Prior to the anesthetic they had been rendered nephritic by the same quantity of uranium per kilogram as was received by the adult animals; and later they received the same quantity of the anesthetic per kilogram as was received by the adult animals.

With this group of animals the experiments were conducted in a manner identical with the group just discussed; the same diuretie substances were employed; and they were given to the animals in this same quantity per kilogram.

The following series of animals which did not become anuric retic response of the two groups.

Experiment 18. The animal before the use of a diuretic had a flow of urine of 1.4 cc. per ten minute interval. Following caffeine, which induced a rise in general blood pressure of 6 mm. of mercury and in oncometer pressure of only 6 mm. of water, the urine flow increased to 2.5 cc., digitalin produced a rise in general pressure of 6 mm. of mercury and in oncometer pressure of 15 mm. of water. The urine flow was increased from 1.1 to 1.7 cc. per ten minute interval, following 0.9 per cent sodium chloride, which induced practically no change in general blood pressure but a rise in kidney blood pressure of 23 mm. of water; the urine flow increased from 2 to 4.5 cc.

A comparative study of these two groups of experiments in which the animals received Gréhant's anesthetic and in which one group becomes anuric and fails to respond to diuretics, while the other group does not become anuric and does respond to diuretics, fails to show any variations in the changes in general blood pressure which could account for the difference in the output of urine.

The changes in the oncometer pressure in the two groups show that the kidney vessels are responsive to substances acting peripherally on these vessels and that they also respond to changes in the general circulation. A general analysis, however, of the pressure changes in the kidney induced by the different diuretics in the two groups of animals shows that in the diuretic animals the changes in the kidney pressure are usually more pronounced than they are in the anuric animals. At the present time experiments are being conducted with the object in view of determining whether or not there is any constant difference in the vascular response of the kidney vessels in the two types of animals.

The difference in the renal pathology of animals anuric and diuretic following Gréhant's anesthetic

In conducting the pathological study of the kidneys from these two types of animals every precaution was employed to eliminate sources of error by using several fixing fluids for the tissue from each experiment and by adhering to a uniform staining technique.

Tissue was fixed in 10 per cent formaline, Zenker's fluid, and in corrosive-acetic. The formaline and Zenker fixed tissue was imbedded in cellodin, while the corrosive-acetic fixed tissue was imbedded in paraffin. Cellodin sections were cut varying between 10 to 15 micra while the paraffin sections used for the comparative study were 6 to 8 micra in thickness. The stains employed were haematoxylin and erosin. In addition to this, frozen sections were made and stained for fat by Herxheimer's Scharlach R. method. As has been clearly shown by Bullard (4) fat proplets in considerable number may be demonstrated by this stain, when Herxheimer's modification is used, which would be missed by the simple alcoholic solutions of Scharlach R. and of Sudan. III.

The following pathological report should be considered as a summary of the essential differences in the kidneys of these two two types of animals. A detailed discussion of the pathology will be published elsewhere.

In adult animals which had been rendered nephritic by uran-

ium and killed by shooting, so as to eliminate the effect of the anesthetic, the kidney shows in the gross a severe congestion of the outer cortex and of the medulla. Between the cortico-medullary boundary zone and the superficial portion of the cortex there is a mid zone which appears distinctly pale as contrasted with other portions of the kidney.

In young animals which have been subjected to a similar experimental technique, this pale zone of the cortex is either absent, or is much less pronounced, while in general the cut surface of the kidney appears uniformly and severely congested.

The histological study of tissue from the kidneys of these two groups of animals which have not received an anesthetic shows a vascular reaction which is manifested by an engorgement of the glomerular vessels, but without any intro-glomerular or intertubular exudate. The epithelium of the tubules shows a shrinkage which gives to the lumen of the tubules an unusual prominence (figure 1 and 2). Thus far the grosser pathological changes in the two groups of animals are similar. The changes, however, differ very strikingly in this respect. The adult animals show a high degree of fatty degeneration in the tubules of the medullary rays and in the distal convoluted tubules, while tissue from the kidneys of the young animals show this fatty change to a much less extent, though when it develops the same tubules are involved. This is one of the striking differences in the pathological response of these two groups of animals.

When adult animals and young animals are anesthetized by the same quantity of Gréhant's anesthetic per kilogram, the gross and microscopic pathology of the kidneys shows the following differences.

In the adult animals the cut surface of the kidney does not show such a severe congestion and the mid-cortical zone of paleness has perceptibly increased in distinctness and extent. The microscopic study shows that the fatty changes which have been induced by the uranium have been very greatly increased by the anesthetic and that the pale zone of the cortex is, in part, due to these changes. As a result of the effect of the enesthetic the epithelium of the tubules of the labyrinth, especially the

proximal convoluted tubules, has become acutely swollen, with a part or complete occlusion of the tubular lumen. The epithelium is in various stages of degeneration and necrosis (fig. 3). The rapidity with which this swelling develops is remarkable.

In the kidneys of the young animals following Gréhant's anesthetic, the same type of changes are induced, but to a much less extent. Thus there develops in the cortex a pale zone which is much less extensive than in adult animals and microscopically the fatty changes in this zone are found to be less pronounced. Equally noticeable as the difference in the fat content (microscopically demonstrable) is the difference in the degree of involvement of the tubules of the labyrinth. In the young animals which have remained diuretic the severe grade of swelling of the epithelium which was so noticeable in the adult animals is comparatively slight or absent (fig. 4).

The difference in the renal pathology of animals anuric and diuretic following morphine-ether

With two exceptions these animals following morphine-ether remained diuretic.

The diuretic group was composed of both young and adult animals. In this group uranium induced the same type of changes as have been described in the animals which were given Gréhant's anesthetic. When, however, morphine-ether was employed as the anesthetic, the fatty changes which had been induced by the uranium were not increased to a degree comparable to the increase in these changes which followed Gréhant's anesthetic, and also the acute swelling of the epithelium of the tubules of the labyrinth was either absent or much less marked (fig. 5).

The exceptions to this statement are found in two animals which were very old; and these animals following morphine-ether showed a pathological response on the part of the kidney which was comparable to the pathology seen in the kidneys of the adult animals which received Gréhant's anesthetic, and like these animals they were rendered anuric.


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GENERAL DISCUSSION OF THE EXPERIMENTAL DATA

The metabolic disturbance which is induced by uranium and which in part is characterized by the development of a glycosuria is usually explained by assuming that this substance like hydrocyanic acid induces the glycosuria by lessening internal respiration.

In the experiments conducted by Chittenden and Hutchinson (5) on the influence of uranium salts upon the activity of certain ferments they were able to show that the nitrate exerted an inhibitory effect upon the ferment action of saliva and of pepsin. This inhibition was induced by the nitrate in very high dilutions. An inhibitory effect on the ferment action of saliva was brought about with dilutions of the salt in 0.0001 to 0.003 per cent strength while the inhibition of the protelytic action of pepsin required the use of the salt in stronger solutions. The action of this ferment was inhibited when uranium nitrate was used in the strength of 0.01 per cent, and all action ceased when the strength of the solution increased to 0.5 per cent.

It is possible that uranium nitrate exerts a similar inhibitory effect upon the action of the oxidative enzymes of the cell, and that through this action internal respiration, even in the presence of abundant oxygen, is interfered with. The lessened oxidation so induced would explain the glycosuria that is constantly seen following uranium injections.

Granting that such a hypothetical explanation for the uranium glycosuria be true, the experiments which have been conducted in this investigation would tend to show that the oxidative capacity of the young animals is greater than that of the adult animals, for when these two groups of animals have received uranium nitrate in the same quantity per kilogram the percentage of glucose in the urine of the young animals is much less than is the percentage in the urine of the adult animals.

When we consider the unusual demand for activated oxygen which likely exists in the tissues of rapidly growing young animals, we see that such an assumption concerning

the relative oxidative capacity of young and adult animals is not especially visionary.

In addition to the evidence of a disturbed metabolism that is manifested by the appearance of glucose in the urine, the use of uranium also induces fatty changes in the kidney and in the liver. So far as their severity is concerned these changes bear the same relation to the age of the animal as was seen to exist for the percentage of glucose in the urine. The fatty changes in the liver and in the kidney are much more pronounced in the adult animals than they are in the young animals.

When these nephritic and glycosuric animals are given an anesthetic, those changes, of whatever origin they may be, which have been induced by the uranium injections become greatly augmented. The percentage of glucose in the urine is increased, the fatty changes in the kidney and in the liver are more marked, and the nephritis is so increased in severity that certain of the animals rapidly develop an anuria.

These changes which are induced by the anesthetic are also influenced by the age of the animal, and they are found to be more pronounced in the adult animals than they are in the young animals. An observation similar to this has been made by Whipple (6), who was able to show that chloroform induced but slight fatty degeneration and liver necrosis in young pups, while in adults a marked central hyaline necrosis of the liver was induced.

Not only does the age of the animals influence the severity of the action of the anesthetic, but the type of anesthetic employed also aids in determining the severity of its effect.

Of the two anesthetics which were used in the experiments, Gréhant's anesthetic gave more evidence of being toxic and had more effect in increasing the severity of the nephritis and in establishing a condition of anuria.

The active anesthetic ingredients in Gréhant's anesthetic are chloroform and alcohol, and from the observation which has just been made, it would appear that of the two anesthetics, Gréhant's and morphine-ether, Gréhant's which con-

tains choloform and alcohol is far more toxic in a nephritis than ether. This would be especially true in those nephritides in which the parenchymatous element of the kidney is principally involved.

A study of the response of the nephritic kidney to diuretics, shows that the efficiency of a given diuretic very largely depends upon the age of the animal, and upon the anesthetic which has been employed. Thus young and adult animals nephritic from uranium, when anesthetized with morphine-ether, remain diuretic to the substances which have been used in the experiments. The same statement holds true for the young animals which were anesthetized with Gréhant's anesthetic. When, however, an adult animal nephritic from uranium is anesthetized with Gréhant's anesthetic the animal becomes anuric and remains refractory to the diuretic substances which have induced a free diuresis in the other animals. A similar condition of anuria with a failure to respond to the diuretics has been observed in two old animals anesthetized with morphine-ether.

The renal pathology which is characteristic of this anuric group consists in a rapid swelling and necrosis of the epithelium, especially of the proximal convoluted tubules.

A physiological study of this anuric group shows that the anuria is not dependent upon a general condition of low blood pressure. The degree of response of the renal vessels to substances acting locally in the kidney and through changes in the general blood pressure is certainly sufficient to influence diuresis in a normal kidney. When compared with the degree of response on the part of the renal vessels in the diuretic animals, it would appear that it was sufficient to induce diuresis in these anuric animals. In the anuric group however, with the pronounced swelling of the epithelium which is constantly present, the quantity of blood reaching the glomeruli and the rate of blood flow through the kidney must be to some extent interfered with. This is likely a part of the explanation for the anuria.

With this cause for the anuria in mind, in these animals

which had remained anuric to diuretics, such as caffeine and 0.9 per cent sodium chloride, hypertonic salt solutions were employed with the object in view of inducing a shrinkage of the swollen cells and by removing any obstruction to the renal circulation and at the same time by removing any mechanical obstruction to the flow of the urine through the partly or completely occluded tubules to induce a diuresis.

When such hypertonic solutions were used, it was found possible to induce a shrinkage of the epithelium (fig. 6). With such a change in the size of the epithelial cells which would tend to decrease the volume of the kidney, the oncometer showed an increase in kidney volume. This rise in kidney pressure is likely due to the dilator effect of the hypertonic solutions on the renal vessels. With this change in the vessels, increasing the quantity of blood reaching the kidney and with the epithelium shrunken the circulation through the kidney should be distinctly improved. Even through such a change in the renal circulation had apparently been induced, the animals remained anuric. Whether or not we have in this anuric type of nephritis, as suggested by Pearce (7), a condition of the vessels which allows dilatation, but in which the vessels are so influenced by the anesthetic as to cause decreased glomerular permeability, it is difficult to say.

In three animals of this anuric group the use of salt solution caused a well marked inter-tubular exudate to be produced. This observation would tend to decrease the probability of Pearce's explanation for the anuria, for it shows that some of the vessels are permeable to salt solution.

The salt solutions were also employed as diuretics for the purpose of renderering the blood more hydræmic and at the same time of decreasing its viscidity. These changes in the blood had no effect in re-establishing a urine flow.

In conclusion, it would appear that in a uranium nephritis when following an anesthetic the epithelium becomes severely damaged, the animal develops an anuria uninfluenced by diuretics which increase the efficiency of the vascular mechanism

of the kidney, and which so alter the composition of the blood as to favor diuresis.

The investigation would, therefore, tend to favor the conception of the kidney's activity being more dependent upon the secretory capacity of its cells than upon any mechanical conception of the action of the vascular mechanism of the kidney.

CONCLUSIONS

1. In dogs in which an acute nephritis has resulted from the subcutaneous administration of uranium nitrate in the dose of 6.7 mgs. per kilogram the severity of the nepritis, of the glycosuria, and of the polyuria is influenced by the age of the animal. The changes in the kidney and in the urine are more marked in adult animals than they are in young animals and in puppies.

2. When such nephritic, glycosuric, and polyuric animals are anesthetized by Gréhant's anesthetic or by morphine-ether, the severity of the nephritis is increased, and the output and composition of the urine is changed.

3. The increase in the severity of the nephritis is more marked from the use of Gréhant's anesthetic, the active anesthetic ingredients of which are chloroform and alcohol, than from morphine-ether.

4. In addition to the fact that the type of anesthetic influences the renal pathology the age of the animal also aids in determining the severity of the changes. The changes are more pronouncel in adult and old animals than in young animals and puppies.

5. Following the anesthetic these nephritic animals either become anuric or remain diuretic.

6. In the anuric group, which is principally represented by the adult animals which have received Gréhant's anesthetic, the condition of anuria is influenced by various diuretics.

7. The failure of this group to respond to diuretics is more likely due to the destruction of the epithelium of the kidney than to any physiological or anatomical change in the vascular element of the kidney.

8. Those animals that following the anesthetic are not rendered anuric are responsive to the same diuretic substances which in the anuric group have been shown to have no diuretic value.

9. In this diuretic group of animals, regardless of whether the anesthesia has been induced by Gréhant's anesthetic or by morphine-ether, the epithelial involvement of the kidney is much less severe than in the anuric group.

In conclusion I desire to acknowledge my indebtedness to Dr. J. P. Jones for his valuable aid in conducting the experiments.

CHAPEL HILL, N. C.

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EXPLANATION OF PLATE

1. Kidney of an adult animal, nephritic, glycosuric and polyuric from uranium. The epithelium is shrunken and gives to the lumen of the tubules undue prominence. The epithelium shows an early vacuolation. The glomerular vessels fill the capsular space. The tubules contain granular detritus.

2. Kidney of a puppy, nephritic, glycosuric and polyuric from uranium. The changes in general are similar to those seen in figure 1.

3. Kidney of an adult animal following Gréhant's anesthetic given in 60 per cent strength. Prior to the anesthetic the animal was excessively polyuric. Following the anesthetic, within forty minutes, the animal became completely anuric. The figure shows the acute swelling of the epithelium with an occlusion of the lumen of the tubules. The epithelium of the beginning of the collecting tubules is spared. These tubules remain open. The glomerular vessels do not fill the capsular space. This figure should be compared with figs. 1 and 4.

4. Kidney of a puppy following Gréhant's anesthetic. The animal had been rendered nephritic with the same quantity of uranium per kilogram as had been used for the adult animal, figure 3. The puppy was anesthetized with the same quantity of Gréhant's anesthetic per kilogram as was the adult animal. The figure shows the absence of epithelial involve-

ment. The tubules are not occluded. The glomerular vessels fill the capsular space. The animal was freely diuretic.

5. Kidney of an adult animal following morphine-ether as an anesthetic, nephritic from uranium. The animal remained freely diuretic. The figure shows the absence of the acute swelling of the epithelium, which was the most characteristic change in the figure from the adult animal anesthetized with Gréhant's anesthetic.

6. Partial shrinkage of the epithelium in an adult anuric animal from the use of hypertonic salt solution. The epithelium is in an advanced stage of degeneration. The glomerular vessels fill and distend the capsule and are histologically well preserved. The animal remained anuric.

Chapel Hill, N. C.

VOL. XXX AUGUST, 1914 No. 2

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OF THE

ELISHA MITCHELL SCIENTIFIC SOCIETY

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JOURNAL

OF THE

ELISHA MITCHELL SCIENTIFIC SOCIETY

VOLUME XXX AUGUST, 1914 No. 2

PROCEEDINGS OF THE THIRTEENTH ANNUAL MEETING OF THE NORTH CAROLINA ACADEMY OF SCIENCE

Held at Trinity College, Durham, N. C., Friday and Saturday, May 1 and 2, 1914

The Executive Committee, President Sherman and Secretary Gudger, *ex officio,* and Messrs. C. S. Brimley, W. C. Coker, and J. J. Wolfe present, met at 2:30 P. M. Friday, May 1. The secretary made his annual report of the finances and membership of the Academy and this was recommended favorably to the Academy at its annual business meeting. The following were elected to membership:

(1) Wm. Battle Cobb, Soil Scientist, U. S. Department of Agriculture, Washington, D. C.

(2) C. M. Farmer, Professor of Natural Science, Atlantic Christian College, Wilson.

(3) E. Oscar Randolph, Assistant in Geology, University of North Carolina, Chapel Hill.

(4) Henry Roland Totten, Assistant in Botany, University of North Carolina, Chapel Hill.

The invitation of the President and Faculty of Wake Forest College that the Academy hold its fourteenth annual meeting as the guest of that institution was unanimously accepted.

An amendment to the constitution adding the vice-president to the list of *ex officio* members of the Executive Committee was offered by C. S. Brimley, discussed by the Committee, and recommended to the favorable consideration of the Academy. The Committee then adjourned.

At 3 P. M. President Sherman called the Academy to order and appointed the following committees: Nominating, H. V. Wilson, W. C. Coker, W. H. Pegram; Auditing, C. W. Edwards, J. D. Ives, and R. W. Collett; Resolutions, C. S. Brimley, Z. P. Metcalf, and W. N. Hutt.

The reading and discussion of papers was then begun and continued until adjournment was had at 6 P. M., when 11 numbers had been disposed of. In attendance were 23 members and a number of visitors.

The academy reconvened at 8 P. M. in the Y. M. C. A. Hall, when, after a hearty welcome to Trinity College from Dean W. I. Cranford, President Franklin Sherman, Jr., of the Academy, gave his presidential address on the subject " Studies of the Animal Life of our State with Suggestions for a Biological Survey (illustrated by numerous charts).

Next, Professor A. H. Patterson delivered a lecture "The Gyroscope and Its Modern Applications," illustrated with some fine apparatus. Then Mr. Bert Cunningham gave a striking demonstration of the new Nitrogen Tungsten lamp, showing it in comparison with the ordinary Tungsten and Carbon lamps consuming the same amount of current.

Following this the faculty of Trinity College entertained the Academy at a much enjoyed smoker.

At 9 A. M. Saturday the Academy met in annual business meeting, with the President in the chair, and some 20 members present. The proceedings of last meeting were read and approved, and the report of the Secretary and Executive Committee were called for. Mr. Brimley's amendment to the constitution, Art. III, Sec. 1, was adopted. This now reads: " . . . and an Executive Committee of *six,* including the President, *Vice-President,* Secretary," the italicized words indicating the change and the addition.

The Auditing Committee reported the books and accounts, and the financial statement of the Secretary-Treasurer to be correct. The Secretary-Treasurer then read his itemized financial statement which is included herewith and showed that the current dues are insufficient to carry the current expenses of the

Academy and that it is now necessary to draw every year on the savings bank account. There was some discussion with regard to an amendment to the Constitution increasing the dues but it was finally decided to let the matter go over until next year.

Chairman Brimley of the Resolutions Committee, reported the following resolutions which were unanimously adopted:

Resolved; (1). That we express our sincere appreciation of the many courtesies and generous hospitality extended to us by the Faculty of Trinity College; (2). That we commend our efficient Secretary for his zeal and assiduity in the performance of his duties; (3). That we express our approval of the recommendations of our President for a Biological Survey of the State and suggest that all our members co-operate in gathering data to further that end.

The Nominating Committee submitted its report and officers were unanimously elected as follows:

President, J. J. Wolfe, Professor of Biology, Trinity College, Durham.

Vice-President, A. H. Patterson, Professor of Physics, University of North Carolina, Chapel Hill.

Secretary-Treasurer, E. W. Gudger, Professor of Biology, State Normal College, Greensboro.

Executive Committee: W. N. Hutt, Horticulturist, State Department of Agriculture, Raleigh; J. H. Pratt, State Geologist, Chapel Hill; W. A. Withers, Chief Chemist, North Carolina Agricultural Experiment Station, West Raleigh.

Chairman Edwards, of the committee appointed in 1912 and continued last year, brought forward the following report on ventilation of public buildings: "Resolved, that the North Carolina Academy of Science recommends that legislation be enacted specifying the minimum standard of ventilation in schools, public auditoriums, and penal institutions in North Carolina and that this committee be authorized to submit to the proper legislative committee all data accumulated by it concerning this matter." This was so ordered.

The question of changing the time of the annual meeting was raised and discussed. Some of the members thought it better to have it earlier in the spring, increasing the time between the meetings and the commencements of the colleges; others advo-

cated having it in the fall about Thanksgiving. Finally, however, the matter was left in abeyance until the next meeting.

The Secretary reported that on January 1st, 1913, there were 81 members; that during the year 15 were lost by withdrawals, removals from the state, and non-payment of dues; and that 12 new members were elected; the number at the beginning of the year 1914 being 78.

At 9:45 the reading of papers was resumed and continued until all were finished and adjournment was had at 12:30. There were 30 papers on the program, of which only two were read by title, the others being given by their authors.

The membership of the Academy at the present time is as follows—those present at the meeting being indicated by a *:

Allen, W. M.; Balcomb, E. E.; Booker, Warren H.; Boomhour, J. G.; *Brimley, C. S.; Brimley, H. H.; Bruner, S. C.; Cain, William; Clapp, S. C.; *Cobb, Collier; Cobb, Wm. B.; Coker, R. E.; *Coker, W. C.; *Collett, R. W.; *Cunningham, Bert; Dixon, A. A.; Downing, J. S.; *Edwards, C. W.; *Farmer, C. M.; *Fulton, H. R.; *George, W. C.; Gove, Anna M.; *Gudger, E. W.; Hammel, W. C. A.; Harding, W. T.; Herty, C. H.; Hobbs, A. Wilson; Hoffmann, S. W.; Holmes, J. S.; Holmes, J. A.; *Hutt, W. N.; *Ives, J. D.; Kilgore, B. W.; Lanneau, J. F.; *Lay, George W.; Lewis, R. H.; McIver, Mrs. Chas. D.; MacNider, W. de B.; *Markham, C. B.; Mendenhall, Gertrude W.; *Metcalf, C. L.; *Metcalf, Z. P.; Mills, J. E.; Newman, C. L.; *Norton, W. C.; *Patterson, A. H.; *Pegram, W. H.; Poteat, W. L.; *Pratt, J. H.; Radcliffe, Lewis; Ragsdale, Virginia; *Randolph, E. Oscar; Rankin, W. S.; Robinson, Mary; *Sherman, Franklin, Jr.; Shore, C. A.; *Smith, J. E.; Stiles, C. W.; Strong, Cora; *Totten, Henry R.; Venable, F. P.; Wheeler, A. S.; Williams, L. F.; *Wilson, H. V.; *Wilson, R. N.; Winters, R. Y.; Withers, W. A.; *Wolfe, J. J.

In addition to the presidential address, which is published in full in this number, the following papers were presented:

ECONOMIC GEOLOGY OF CHAPEL HILL, N. C. AND VICINITY.

JOHN E. SMITH

GENERALIZED SECTION OF MANTLE ROCK.

1. Soil, "Top Soil," red to gray or black.................... 1 to 3 feet
2. Subsoil, fine, somewhat compact, red to yellow clay...... 3 to 10 feet
3. Clay, coarse and lumpy, with some sand.................. 5 to 20 feet
4. "Natural Sand-Clay," feldspar, quartz, sand and clay....10 to 20 feet
5. Fragmental Rock, angular, decayed, size 2 to 4 inches....10 to 20 feet
6. Fragmental Rock, coarser and fresher than that in 5.... 5 to 15 feet
7. Granite, "Bed Rock," "Country Rock."

This region serves as a type for Piedmont areas in which granite is the underlying rock—about one-third of the Piedmont Belt.

Zone No. 1 is the surface soil of the upland and is used in agriculture and in road building. No. 2 provides clay suitable for brick and tile. As the topography is mature and these zones have been removed by erosion from much of the area, the value of the land is low. The material of zone 4 makes good sand-clay roads. This is approximately horizontal and outcrops on the slopes where valleys have been cut below its depth. Stream sand is used in making mortar and in road construction.

This mantle rock forms an excellent filter and most wells in it are free from contamination. Excepting the mountain region, these are the most healthful areas in the South.

AN ACHLYA OF HYBRID (?) ORIGIN

W. C. COKER.

An Achlya was described from Chapel Hill, N. C. with pecularities that suggest a hybrid origin. The tips of the hyphae often die and the growth is then extended as a side branch below the dead tip. The spores show a strong tendency to poor organization, the protoplasm often segregating only imperfectly, and producing irregular masses of various sizes. The same is true of the eggs, which are of any size and almost never become perfectly organized, and die quickly. The plant seems most like *Achlya polyandra* Hildeband, but differs from it in the walls of the oogonia being pitted and in the abnormal behavior of the eggs.

It is suggested that the plant may be a hybrid between A. *DeBaryana* Humphrey and A. *apiculata* DeBary.

THE NURSE SHARKS OF BOCA GRANDE CAY, FLORIDA.

E. W. GUDGER.

Boca Grande Cay is an island of coral sand and mangroves lying about 20 miles west of Key West. Situated on a shallow submarine platform, about 120° of its circumference is surrounded by sand flats inhabited

largely by sting rays. Another 140° of its circumference is bounded by a shallow gently sloping rock bottom on which the water a half mile from shore will not be over a man's shoulders. On this rocky bottom, the nurse sharks, *Ginglymostoma cirratum*, come out to bask in the sun, to play, to breed, and possibly to feed. Here they are found in large numbers. A dozen can be seen at almost any time, and 33 have been counted in the sweep of the eye.

These sharks in looks and habits much remind one of well fed pigs in a barnyard. They are much broader in the pectoral region than ordinary sharks, are sluggish in their movements, and are comparatively unafraid of man. They frequently lie in water so shallow that their dorsals project above the surface, and a number of times they allowed the boat to drift down over them and strike their fins before they would move.

They lie with heads on each others pectorals or tails, or one will have his snout elevated on another's flank, or they will lie heads and tails together or in a confused herd. Here again this similarity in habits to barnyard pigs is very noticeable. Further they often swim one after another to the number of three or four in an aimless fashion, each one following the purposeless turnings of its leader.

They are perfectly harmless. Their mouths are small and filled with small pointed teeth. They are omniverous in feeding, like most sharks, but their food seems chiefly to be crustacean, probably consisting of the large spiny "crawfish" common on the reef and on rocky bottom of any kind.

Under the circumstances noted above, there is, of course, no difficulty in killing these sharks. Ordinarily shark fishing is good sport, but killing nurse sharks is no more exciting than sticking pigs in a barnyard. Indeed the Key West fishermen contemptuously speak of them as "Nurses", and of the other sharks as "sharks".

Work on the habits and embryology of this shark is being carried on under the auspices of the Marine Laboratory of the Carnegie Institution of Washington situated at Tortugas and will be continued this summer.

FLOWERS AND SEED DEVELOPMENT OF SPECULARIA PERFOLIATA.

H. R. TOTTEN AND J. A. MCKAY.

There are two kinds of flowers, conspicuous open ones with normal corollas and small bud-like flowers that never open. The last or cleistogamic flowers were described carefully by von Mohl, as long ago as 1863.

It is the object of this paper to give the development of the seeds in the cleistogamic flowers. The seeds are of the same size and appearance as those borne in the open flowers. Four megaspores are formed and

the embryo-sac develops from the lower one. It is surrounded by a single nucellar layer and one thick integument. The endosperm nucleus forms a cellular endosperm from the first division. The young endosperm sends out a knob-like haustorium of one or two cells at each end. The suspensor of the embryo grows up into the micropylar haustorium, to some extent, forming a small enlarged knob there. As the seed grows the haustoria are encroached upon and destroyed.

STUDIES IN THE TOXICITY OF COTTONSEED MEAL

W. A. Withers, R. S. Curtis and G. A. Roberts

About one-hundred and seventy-five hogs were fed upon cottonseed meal or some fraction of it. The swine died in every case after eating the meal for periods ranging on average from 59 to 96 days. Twenty-two rabbits fed on cottonseed meal died on average of 13 days.

With different solvents used, the extract was usually nontoxic and the residue usually toxic.

Green feed, liberal exercise and ashes seemed to be of some aid to pigs in overcoming the toxic effect of Cottonseed meal. Treatment of the meal with an alcoholic alkali rendered the meal non-toxic to rabbits.

Citrate of iron and ammonia was effective with rabbits and ferrous sulphate was effective with swine as an antidote to the toxicity of cottonseed meal.

THE LOCUST TREE CARPENTER MOTH, A FORMIDABLE PARASITE OF THE OAK.

J. J. Wolfe.

In February, 1911, a white oak about fourteen inches in diameter, on the campus of Trinity College was seen to be severely injured as a result of the boring habits of what proved to be the larvae of *Pryonoxystus robiniae,* commonly known as the locust tree carpenter moth. The tree was cut and sections of the trunk split into two pieces. Numerous winding tunnels were found throughout the heart and sap wood of the trunk and larger limbs. From these were collected fourteen larvae of three distinct sizes—a fact supporting the view that the insect requires three years for its development. A portion of the trunk near the ground was riddled with holes—points of exit—in which wood destroying fungi had established themselves and threatened the destruction of the tree.

The insect attacks several trees of the street, park and forest. Its habits render it a formidable pest. Means for its control on any large scale are at present wanting, but sporadic occurrences in trees of streets and parks might possibly be held in check by injecting into these tunnels a volatile poison and then plugging them with some waxy substance.

THE PECAN TWIG GIRDLER.

C. L. METCALF.

A detailed account of the egg-laying habits of *Oncideres cingulata* Say. The preliminary and supplementary maneuvers habitually performed (which result in the severing of numerous twigs from the tree in which the eggs are laid); with a brief account of the life-history, economic importance and methods of control of the pest in commercial pecan orchards.

A ROUGH METHOD OF RECORDING SEASONAL DISTRIBUTION.

C. S. BRIMLEY.

The method I am about to describe is not meant to take the place of full records or complete data with regard to any group of living things in which one is particularly interested, but rather to provide a convenient means of summarising such records and also to record data concerning animals or plants in which one is less interested and therefore is not likely to take much trouble about.

The method is briefly this, rule the left-hand pages of a blank book into 12 vertical columns, leaving enough space on the left for the names of the species to be recorded, and leaving the right hand page blank for any additional data. At the head of these twelve columns write the abbreviations, Jan., Feb., Mar., Apl., May., Jun., Jly., Aug., Sep , Oct., Nov., Dec., and when you have a record to make of a species, record it by the appropriate letter of the month in the column for that month, J. standing for early January, a for middle January, n for late January and so on, "early" signifying from the first to tenth inclusive, middle for from eleventh to twentieth, late from twenty-first to end of month.

I have hundreds of species of insects recorded in this way and the records are both easy of access and very serviceable when one wishes to find at what period of the year any particular insect is likely to occur. Of course, separate records could be kept for each year and should, of course, be kept for different localities, but as a matter of course such a system would necessarily come into use mainly for the locality in which one spends the greater part of one's time.

SOME RARE PLANTS AND SINGULAR DISTRIBUTIONS IN NORTH CAROLINA.

W. C. COKER.

Announcement was made of the addition of a new tree to the flora of North Carolina. The Pin Oak (*Quercus palustris* DuRoi.) was found near Chapel Hill by Mr. J. S. Holmes, State Forester, in the fall of 1913.

Rhododendron catawbiense Michx., supposed to be confined in this

state to the tops of the highest mountains, was reported as growing at Chapel Hill, Hillsboro, and other places in Orange county, and stranger still at Cary (near Raleigh), and even at Selma which is well within the coastal plain.

Venus' Fly Trap (*Dionaea muscipula* Ellis.). Evidence as to distribution of this remarkable plant was reviewed and it was concluded that that species is distributed from Buckville, S. C., to New Bern, N. C., and westward along the Cape Fear River to Fayetteville.

The tuberous variety of Tall Meadow Oat grass (*Arrhenatherum elatius* (L) Beauv., var. *bulbosum*) was exhibited from Chapel Hill. This is a recent introduction from Europe where it is known as a troublesome weed. Within the last three years the U. S. Department of Agriculture has received it occasionally from Virginia to Georgia.

Blessed Thistle (*Cnicus benedictus* L.) was shown to be a troublesome weed in Chapel Hill grain fields.

Euonymus atropurpureus Jacq. This is found to be one of the rarest shrubs in North Carolina, and known with certainty only from Chapel Hill.

THE LAWN PROBLEM IN THE SOUTH.

W. C. COKER AND E. O. RANDOLPH.

This paper attempts to find some way of solving the hard problem of lawn making in the South. Observations were made on many lawns, with various conditions of soil, exposure and care, to determine the grasses and weeds actually present. About six of the most promising grasses were carefully studied to determine their value and use as lawn cover.

Exhibits were made in trays of good sods formed by these six grasses, and also of some of the worst lawn weeds.

No abstracts have been received for the following papers:

Movements of Plants—J. D. Ives.

A Report on Local Protozoa—Z. P. Metcalf.

By Raft and Portage—A Study in Early Transportation in North Carolina—Collier Cobb.

The Case of the Riparian Owner—R. N. Wilson.

Some Philippine Sponges—H. V. Wilson.

Economic Minerals in the Pegmatite Dikes of Western North Carolina —J. H. Pratt.

The Sclerotinia Disease of Clovers and Alfalfa—H. R. Fulton.

The Use of Home-made Models as an Aid in Teaching Embryology—W. C. George.

Electrical Conduction of Flowing Mercury—V. L. Chrisler, presented by A. H. Patterson.

Microscopic Demonstration of Protozoan Spores, Used as Proof of Contamination of Food with Human Excrement—C. W. Stiles.

Some Recent Developments in the Theory of X-Rays—C. W. Edwards.

The Gyroscope and its Modern Applications (with a demonstration)—A. H. Petterson.

The Coggins Gold Mine—J. H. Pratt.

Geology in Relation to the Location of Highways in North Carolina—Collier Cobb.

The Corn Bill Bug—Z. P. Metcalf.

A Peculiar Case of Freezing—R. N. Wilson.

The Nitrogen Tungsten Lamp—Bert Cunningham.

E. W. GUDGER.
Secretary

STUDIES OF THE ANIMAL LIFE OF NORTH CAROLINA WITH SUGGESTIONS FOR A BIOLOGICAL SURVEY*

FRANKLIN SHERMAN, JR.

When it became known to me that the North Carolina Academy of Science, at its last meeting (which I did not attend) had made the mistake of thrusting upon me the presidential honors for this session,—one of the first questions that arose in my mind was as to the topic, subject-matter and method of presentation of the annual address. I have had special misgivings upon this subject because of the fact that my immediate predecessor, Mr. C. S. Brimley, has tastes and views so similar to my own, that I feared that the thoughts which I might present would bear almost too close a resemblance to his. It is already known to some of you that Mr. Brimley and myself have been for some years accumulating records, data, and specimens bearing upon the occurrence and distribution of the native animals of the state. At our meeting in Greensboro in 1908 we presented a joint paper on the Life Zones of the state. Both of us have (both at these meetings and in technical journals) presented lists and data bearing on this topic, and Mr. Brimley's Presidential Address a year ago upon the subject of "Zoo-geography" laid further emphasis upon this subject.

In the hope that through the activities of the Academy, the individuals thereof, and the institutions represented in its membership, we may be able to place these and related studies on a better footing, and in the further hope that the topic may carry some measure of interest to our visitors on this occasion, I now venture to open the subject of this address.

When any person, scientist or layman, has his interest aroused by any new, strange or interesting plant or animal, among the first and most natural questions are these: What is its name? Does it normally live and thrive in this locality? Where else does it occur? At what seasons are its activities evi-

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dent? Is it really rare? What are its economic relations, that is, is it beneficial, or harmful, or merely neutral? And if is neutral, or practically so, on which side of the balance would its weight be felt if it should in future increase to excessive numbers?

These are logical and reasonable questions, and such as the public might expect biologists to be able to answer. Yet at present this information in any detail at least, is lacking for the majority of our native animals. North Carolina is not poorer in this respect than most other states, but it wuold seem to be a reasonable ambition to assemble and publish such facts and data, as would give us some reliable source for reference on such matters.

A very little sincere study will show any student that the general public has little or no really definite knowledge to offer on these questions. For example, among our native animals no group is more appreciated than the birds, yet if we ask even an intelligent layman to name the birds which he positively knows at sight, we will find that his list is pitifully scant, and his knowledge of these few indefinite. Even our favorite Mocking-bird is often confused with the Logger-head Shrike, a bird whose habits are totally different and which resembles the Mocker only in superficial appearance. A single female of the Rusty Blackbird would certainly often pass as a "Catbird," the whole group of dull-colored but interesting and important Sparrows pass by such indefinite and misleading names as "bush sparrows" and "field birds," and the large family of Wood-warblers, which is the most gaily colored group of all and one of the most abundant in individuals and species,—is scarcely known at all except to bird students.

And if this is true in the field of Ornithology, which is one of the most popular of all the branches of Biology, how much more is it true of the other branches, especially those which deal with the so-called "lower" and more obscure groups of animals, and of plants? Even the most intelligent farmers have very little really definite knowledge of the weeds which annoy them, or of the insects which attack their crops.

We can never expect that the general public will become really well informed on the subjects, but it is certainly in line with our duty as specialists in the study of these problems that we should aim to make this definite and exact information available not only to ourselves but to our co-workers and to such other persons as may be sufficiently interested to study these subjects as amateurs.

As soon as a group of animals (or plants) is proven or suspected to be of economic importance it becomes a fit subject for study by our recognized institutions, and results of such study usually find a ready means of publication in the bulletins and reports of agricultural or educational institutions. But data upon subjects the economic application of which is or seems to be remote, cannot so easily find a place for publication, especially if they deal with strictly state or local matters. Yet every student knows how difficult it is to draw the line clearly between what is, and what is not, of economic bearing. Even an inconspicuous form of life with apparently no economic relations, may on occasion prove to be important, hence if our studies are really to be broad we must include forms which for the present appear to be of no account. Recent developments in the field of Medical Entomology will make this clear. Only a very few years ago the common House-fly was regarded merely as an insect which annoyed us at times, but which was popularly believed to "keep the air pure"; but now we know that its life is associated with filth and is fraught with almost endless possibilities in the spread of serious diseases of mankind. The Mosquitoes comprise another group of insects which we formerly regarded merely as annoying, but which we now know to be concerned in the spread of both malaria and yellow fever, and much of the sanitary work now being done in Cuba, Panama and other tropical and sub-tropical localities is aimed at mosquito control. A few years ago an exhaustive study of the mosquito fauna of a state (North Carolina for instance) would have aroused skepticism and ridicule so far as its economic aspects were concerned,—now it appears highly desirable. Several states have made more or less exhaustive studies of the subject, notably

New Jersey, and even in North Carolina, both the State Board of Health and the Public Health Service at Washington are making studies.

Fortunately for the present day scientist, the public is rapidly coming to realize that an exhaustive study of what at first seem to be even the most abstruse subjects may ultimately yield results of far-reaching import, especially if they have to do with natural laws or principles upon which all of our life and our activities are dependent. The microscopist studying forms invisible to the naked eye may appear to be interested in matters which are of literally small concern, but it was just such studies that laid the foundations for all of our present knowledge of bacteriology and verified the existence of bacteria themselves.

Broadly speaking, the students of American fauna are divided into two great schools: (1) Those who are interested primarily in the study of principles of life, death, reproduction and development,—experimental biology and morphology, and (2) Those who are interested primarily in knowing the numerous species themselves, their classification, distribution over the earth, and the seasons during which they may be found. It is more especially this latter phase of the subject to which I now invite your attention:

Parker and Haswell (1897) have divided our animal kingdom into 12 branches or phyla. All of what we popularly know as the " higher " animals, fishes, batrachians, reptiles, birds and mammals (including man) fall into one of these 12 phyla. Were I preparing this discussion for an audience of strictly technical zoologists, scientific accuracy would demand that I discuss them in proper scientific order, but as it is the function of this address to put ideas into shape so that they may be understood by persons not technically interested, I shall for the purposes of this discussion, divide our fauna (animal life) into seven groups as follows:

Invertebrates (no backbone)	1. Marine Invertebrates.
	2. Fresh-water and Land Invertebrates—not insects.
	3. Insects.

Vertebrates (with backbone):
4. Fishes.
5. Reptiles and Batrachians.
6. Birds.
7. Mammals.

Thus all the invertebrated animals, which are technically divided into eleven groups, are here put into three, and the vertebrated animals which technically comprise only one group, are here for easier understanding, divided into four.

In this division we must remember that there is much overlapping of forms, especially in the water-inhabiting invertebrates, for a single zoological group may contain some species living in fresh water, and others which are strictly marine.

What progress has been made in the study of what our state affords in these several groups? Remembering that several of these groups contain thousands of species, my hearers will excuse me if I fail to discuss all the groups in full detail.

I. Marine Invertebrates

This group includes thousands of small, little-known forms of life, along with a host of larger and better-known forms. Such work as has been done in listing and making known our species has been chiefly at the government Biological Laboratory at Beaufort where there are special facilities for work. Dr. H. V. Wilson, of the State University, informs me that the sub-groups of this group which are best known from the systematic standpoint are:

The Coelenterates (Jelly-fishes, Sea-anemones, Corals, etc.)
Echinoderms (Star-fishes, Sea-urchins, Brittle-stars, Feather-stars, Sea-cucumbers.)
Crustacea (Crabs, Lobsters, Shrimp, etc.)
Mollusca (Bivalved shells, Conchs, snails, etc.)

Dr. Wilson informs me that the larger forms of Crustacea will be thoroughly listed in a paper soon to be published by Dr. Hay, of Washington, and Dr. Shore, of Raleigh. This list includes parts of several of the most important zoological groups, but leaves the whole group of one-celled animals largely unex-

plored, except that the marine forms have been partially studied at Beaufort by Professor Edmundson of the University of Oregon. Comparatively few of the marine worms appear to have been recorded, much less has the geographical range of these on our coast been worked out.

Our three prominent capes, Fear, Lookout, and Hatteras, each presumably mark the northern or southern distribution of certain species of marine and coast-inhabiting animals. Perhaps no other one locality on our coast offers so good a field for systematic collecting as Beaufort, but the thorough student of the distribution of our coast forms would wish to explore both sides of each of these three capes.

Studies from the morphological side of the subject have been conducted among the Porifera (sponges), the leader in this being Dr. Wilson, of our State University, also in the Coelenterates, Echinoderms, and larger species of Crustacea.

II. LAND AND FRESH-WATER INVERTEBRATES,—NOT INSECTS

Such common forms as earth-worms, snails, crayfish, centipedes, millipedes, spiders, ticks and mites are here included. Entimologists incidentally accumulate some knowledge of millipedes, spiders and ticks on account of their obvious affinities to, or association with, insects,—but the true worms and snails have been very little studied, though every person in this audience has known them from childhood. Verily, it is often the commonest things of which we know the least. If I could advertise, and here place on exhibit even the smallest bit of entirely lifeless matter genuinely known to have come from the planet Mars, I doubt not that this hall would be crowded with persons eager to quench their thirst for knowledge by gazing at the specimen, yet many of those same persons would not know that some of the common snails in our gardens naturally have a shell, while other common snails naturally never have a shell.

Mr. C. S. Brimley has studied the spiders and millipedes of Raleigh to some extent, and Mr. Nathan Banks, of the National Museum at Washington, has collected spiders quite assiduously for several weeks in the vicinity of Black Mountain, but

here our knowledge of the state fauna in this group comes practically to a standstill, save for some earlier accounts and descriptions of our spiders published by Mr. Hentz, and by Prof. Atkinson.

III. INSECTS

We now come to a group which in numbers of species far out-ranks all others, indeed, it far out-ranks all others combined. Aproximately four-fifths of all known species of animals are insects. Furthermore in their economic aspects they are extremely important, not only as pests to crops, domestic animals and to man, but also as carriers of important diseases. A few have been domesticated to form distinct commercial assets, such as the silk-worm and the honey-bee, while others are useful as natural enemies of the destructive sorts.

It is but natural that so important a group as this should attract students, and not only are there amateur entomologists (though very few in North Carolina), but both Federal and State governments have seen fit to employ persons in the study of this group,—mostly on the purely economic questions involved,—but to some extent on the systematic and morphological sides as well. And it is essential that a student in entomology should have some knowledge of insect classification, else he will surely become entangled, confused and seriously misled among the innumerable closely related species. It has been an ambition of the speaker to contribute in some degree toward making known the insect fauna of the state, and in this effort he had help not only from those officially associated with him, but from Mr. C. S. Brimley, of Raleigh, Rev. A. H. Manee, of Southern Pines, and from specialists in other states who have identified many specimens and who in some instances have taken an actual part in exploring our rich and varied insect fauna.

For our purposes we may consider our Insects as falling into seven principal groups, though there are several other smaller groups, some of which fall readily into one or another of the seven, and some of which do not.

The seven main groups are:

1. Roaches, Crickets, Katydids, Grasshoppers, etc., *Orthoptera.*
2. Cicadas, Scales, Plant-lice, Squash-bug, Electric-light bug, and relatives, *Hemiptera.*
3. Dragon-flies, May-flies, Stone-flies, etc., *Neuroptera.*
4. Moths and Butterflies, *Lepidoptera.*
5. House-fly, Mosquitoes, Gnats, and relatives, *Diptera.*
6. Beetles, hard-shelled, with wing-covers meeting straight down back, *Coleoptera.*
7. Ants, Bees and Wasps, *Hymenoptera.*

(1) The first group is decidedly the smallest in number of species and is one of the easiest to collect and study owing to the average large size of the insects, and the ease with which many of them can be collected. The group is of some active, and great potential, economic importance. Owing to the fact that few if any of our species ever indulge in long sustained flight or migrations, they are good subjects for the study of distribution. For all these reasons the group has received some special attention.

The recorded state fauna in this group, includes approximately 160 species. Analyzing our card-catalogue data, we find that these records are drawn from exactly 102 post office localities, counting distinct mountain peaks as localities. But that many of these are merely isolated, scattering records is shown by the fact that only eighteen localities are credited with 15 or more species, only nine show more than 25, while only two show more than 50 species. Raleigh, with 115 species is the only locality whose species are at all fully recorded. Asheville comes next with about half of its probable forms listed. Southern Pines, Waynesville, Blowing Rock and Wilmington have enough records to give a fair idea of their characteristic forms, but in all of these, save possibly Raleigh, a large share of the smaller and rarer forms still awaits discovery by the careful student of distribution. So while the list of species for the state as a whole is fairly complete we are much lacking in data as to the exact range of the species within the state as well as the exact seasons during which they may be found. And to my mind the listing of our fauna, to be at all complete, should not only include the species occurring but also show their geographical and seasonal distribution. A list of species if at all com-

plete is enlightening, but it becomes vastly more useful if it also shows where and when the species are to be found.

Let us see to what extent the geographical range of this group as a whole has been determined for our state. On this point we can indicate the recorded distribution of 155 species.

Records indicating distribution over whole state	28 species.
Records indicating distribution on coast only	1 species
Records indicating distribution in eastern half	22 species.
Records indicating distribution in central portion	11 species.
Records indicating distribution western half	16 species.
Records indicating distribution mountains only	20 species.
Recorded from few scattered localities	19 species.
Recorded from only one locality	38 species.

Remembering that we are now discussing a group of insects which has immense latent powers for evil, it can readily be seen that this kind of data, the more complete the better, can be drawn upon in defining the area where damage is likely to be serious when any species threatens. If a grasshopper suddenly becomes a pest in any locality we have a valuable clue to the possible ultimate meaning of the outbreak if we know the distribution of the species. If thorough records were available for all we might say of any one species:

"This insect occurs only in such and such an area, hence persons outside of this area are free from danger by it except by its possible migration or artificial spread." Without such definite and comprehensive data we must wait for each outbreak to show us, after the fact, just where each species is capable of damage. This same kind of definite information as to the distribution of all other groups of animals could be drawn upon in the same way. This group merely serves as a type to illustrate the point. Every man engaged in scientific work knows how dangerous is the policy of off-handed and unguarded declaration, but when one has his opinions backed by ample evidence secured by painstaking study of the facts, even his guess is of value.

(2) In the second group of insects, including the true bugs, a very considerable body of data has been accummulated, though

up to the present, only a portion has been published. A very consederable portion of the group is under study by Prof. Z. P. Metcalf, and other portions are well represented in the collections of Mr. C. S. Brimley, and the State Department of Agriculture.

(3) The third group, including the Dragon flies (also known as Mosquito hawks), May-flies, Stone-flies and related forms, is of relatively little economic importance, though many of them are of extreme biological interest. Mr. Nathan Banks, of the National Museum at Washington, found enough of interest in the North Carolina material submitted to him, so that he published a list of the state species known to him. In the introduction to his paper he says:

"North Carolina has a large and interesting Neuropterid fauna, and of particular interest is the Panorpodes, a genus elsewhere known only from Oregon and Japan." Mr. Banks has since done considerable collecting in vicinity of Black Mountain.

Of the sub-groups here represented our Dragon-flies (also appropriately known as "Mosquito Hawks") are perhaps best known. As these insects are water-breeders the species are more abundant in the east. Our approximately 100 species are recorded from nearly 50 localities, and certainly include the majority of species, yet the real Dragon-fly fauna of only one locality (Raleigh) it at all thoroughly known (67 species), Southern Pines and Havelock have a record of 32 to 39 species each, Lumberton shows 20 on record, while all the other localities show only a few each.

(4) The Moths and Butterflies comprise the most popular of all the groups of insects, on account of both the beauty and harmlessness of the adults. The Moths especially are of economic importance as the caterpillars of many are very destructive. The larger Moths occurring at Raleigh have been collected by Mr. Brimley and some have been published, but there are a host of smaller, hard-to-identify species which have been by no means thoroughly worked up. The day-flying Butterflies are better known though some additions are yet to be made in the "skipper" group of Butterflies.

Of Butterflies our list records about 115 species, and the records are from numerous localities over the state. Raleigh and Tryon lead with from 80 to 89 species. Cranberry and Southern Pines show 58 to 65 species. Localities showing from 20 to 32 species are: Beaufort, Lumberton, Goldsboro, Blowing Rock, Hendersonville and Andrews. These localities are sufficiently scattered and include a sufficiency of species to give us a reasonably satisfactory knowledge of the distribution (both geographical and seasonal) of most of the species. With the Butterflies our knowledge is if anything more nearly complete than for any other group of insects, though it is a relatively small group of relatively conspicuous insects, hence the data does not involve as laborious work as with some of the other groups.

Recorded from whole state	38 species.
Mountains only	12 species.
Westward but not confined to mountains	13 species.
Coast mainly	2 species.
Eastward but not in mountains	14 species.
Local and Scattering	28 species.

Here, as in the group containing the grasshoppers, we find that a very considerable portion of our species show a more or less definitely marked area over which they may occur.

(5) The True Flies comprise another very extensive group, many of which are small and delicate, hence their study presents special difficulties. But they are of much economic importance, especially in the light of recent discoveries of the part which the blood-sucking and house-inhabiting species play in the spread of human diseases. From the standpoint of Medical Entomology this is the most important group of all, so far as present knowledge goes. The group is quite well divided into a large number of families, a few of which have been studied to some extent, the Horse-fly family perhaps the most thoroughly of all. Of this family 41 species are on record for Raleigh, and about 28 each for Southern Pines and Havelock, with lesser numbers from a host of other localities.

The Mosquito fauna of the state is not yet well known, though there are indications that the present activities in health work will sooner or later give us some substantial knowledge of our forms and their distribution. Out of a fauna probably

numbering 35 species we only have positive record of a little over half that number. But as showing what striking facts even a little study of a state fauna may reveal, I may say that when Mr. Brimley began to collect the mosquitoes of Raleigh he soon found that the genuine yellow fever mosquito is one of our very commonest late summer varieties, in fact at times outnumbers any other. How widely is it distributed over the state? That we do not know, but it is just such information that a comprehensive biological survey of the state might furnish. Wherever that species of mosquito occurs, yellow fever might become epidemic if a victim of the disease should come into the locality, where it does not occur the disease could not become epidemic, according to present knowledge. Nor is the distribution of our malaria-carrying mosquitoes by any means fully known. Hence the need of more study on this group, as with the others also.

The large and beneficial family known as Syrphus-flies is being studied by Mr. C. L. Metcalf, and already our state list will compare favorably with that published for any other state.

(6) The Beetles comprise several thousand North Carolina species, only partially known as yet. Southern Pines and Raleigh have more species recorded than any other localities. The good showing of Southern Pines is due to the activities of Rev. A. H. Mance, who has collected upward of 900 species of beetles in that one locality. Many of the Southern Pines records in other groups are based on material collected by him. Working alone except for the help of specialists far from his locality, without access to large libraries or collections, Mr. Manee has nevertheless contributed a large number of interesting records.

I have said that this group has many species. As proof of this I may say that our card-catalogue now has credited to Southern Pines 845 species of beetles, to Raleigh 697 species, to vicinity of Waynesville 284 species, while very material contributions have come from Cape Hatteras, Beaufort, Chapel Hill, Greensboro, Hendersonville, Asheville, Lake Toxaway, Round Knob, Highlands, and Blowing Rock, and lesser numbers from other localities too numerous to mention. Much material in the group has never yet been identified nor recorded.

Considerable unrecorded collections have been made by Mr. Fiske at Tryon and by Mr. Beutenmuller among the Black Mountains. So it can be truly said that while our records may look formidable to the layman they in reality represent only a fair start on the list of beetles for the state.

(7) In the group comprising the Ants, Bees and Wasps very little thorough work has been done, and still less has been published. A paper on the "Ants of North Carolina" by Dr. W. M. Wheeler has been published, based largely on material collected by Mr. Beutenmuller in the Black Mountains. This group as a whole is beneficial and only a small proportion of the species are even potentially threatening to agriculture, and as many of them can sting, the collecting of them is attended by a certain degree of difficulty. Hence it happens that up to the present no resident collector of the state has become especially interested in the group, and many hundreds of our native forms are yet unrecorded.

Aside from the records from specified localities, our records show many species of insects which are credited merely to "North Carolina," with no indication of the locality where, or season when, they were collected. Such records are for the most part relics of the earlier days when collectors had not yet realized the value of locality and season records. But we now fully realize that to say that a specimen came from "North Carolina" means very little, for a considerable number of our eastern insects show affinities with the fauna of Florida, while many from the mountains suggest the fauna of Canada or the White Mountains of New England.

It would not be fair to leave this consideration of our insect fauna without naming some of those whose labors have added most to our knowledge. Of persons from outside the state who have collected here may be mentioned Prof. Morse of Wellesley College, Mr. C. W. Johnson of Boston, Mrs. Slosson of Staten Island, Mr. Beutenmuller of New York, Messrs. Laurent, Rehn and Hebard of Philadelphia, and Messrs. Hubbard, Schwarz, Banks and Fiske of Washington. Of outsiders who have identified a material portion of our difficult species may be mentioned Messrs. Schwarz, Heideman, Banks, Dyar, Coquillett,

Caudell, Crawford and Barber of Washington, and Professors Osborn and Hine of Ohio State University. Helpful lists of North Carolina material in their collections have been received from Cornell University, and from Messrs. Englehardt, of Brooklyn, Nason of Illinois, and Fenyes of California. Of persons now or in the past resident in the state and from whose work valuable help has come are: Mr. H. K. Morrison, formerly resident at Morganton; Prof. G. F. Atkinson of Cornell, formerly at our State University; Rev. A. H. Manee at Southern Pines, Mr. C. S. Brimley of Raleigh, and several men who have been associated with the speaker in the State Department of Agriculture, notably Messrs. Bentley, Woglum, Z. P. Metcalf and more recently his brother C. L. Metcalf. Doubtless there are others whom I have not mentioned but this is enough to show that the work upon our insect fauna has been by no means a one-man task. Merely a good start has been made upon this enormous, complex and yet highly important group.

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We now come to the vertebrated animals, forms with which we are more familiar, but in which each group contains, as compared with the insects, only a small number of species. First of these is the fishes.

IV. THE FISHES

While North Carolina is well supplied with streams and these streams are inhabited by a representative variety of native fishes, yet the vast majority of species which can be claimed as belonging to the fauna of the state, are found in our coastal waters. Fresh-water forms have been collected in the past by Messrs. H. H. and C. S. Brimley, and by such world authorities as Jordan and Everman, but it was not until after the establishment of the Biological Laboratory at Beaufort, that comprehensive data began to accumulate in regard to our marine forms, and it remained for Dr. Hugh M. Smith, U. S. Commissioner of Fish and Fisheries, to bring the data together in the "Fishes of North Carolina," published by our Geological and Economic Survey in 1907. It is indeed a splendid volume, and sets a high standard for works of this kind, and places our

recorded fish fauna upon a plane where it will compare most favorably with any other state. Dr. Smith acknowledges help from many co-workers, among them the Messrs. Brimley, and Prof. Gudger and Dr. Wilson of our Academy of Science.

V. REPTILES AND BATRACHIANS

The species of this group furnish a most excellent basis for studies in geographical distribution as they do not migrate to any considerable extent. While the number of species is not great many of them are of secretative habits, and as the group as a whole bears a rather unfavorable reputation, few persons have undertaken the serious study of our native forms. In no other group of animals is there so much of popular misunderstanding, superstition, unfounded tradition and fear.

A few specialists from outside have taken an interest in our fauna in this group, but the bulk of our data, which is now considerable, has been both secured and preserved by our fellow-member and proficient herpetologist, Mr. C. S. Brimley. Our reptile fauna is richest in the east, the batrachians are more evenly distributed over the whole state with many species confined to the mountain springs and rills. The forms occurring at Raleigh and Havelock are reasonably well known, and of those at Wilmington, Kinston, Black Mountain, Blantyre (Transylvania Co.), Andrews (Cherokee) and Sunburst (Haywood), the study is well advanced, while lesser but material contributions to what is known come from a number of other well-distributed and significant localities, including Beaufort, Cape Hatteras, White Lake (Bladen), Southern Pines, Greensboro, Winston, Highlands, Blowing Rock, Roan Mountain and Burnsville.

Here again I may call attention to a gap in our knowledge of an important animal. The Coral Snake, which is a poisonous species, is generally reputed to range from about Charleston, S. C., to the southward. There is one recent, authoritative record of its occurrence at Southern Pines. Presumably it occurs sparingly in other parts of our south-eastern area, but exactly where it does occur, no one knows. The distribution of

our other poisonous snakes is only partially known in detail, though the general regions inhabited by them can be defined.

VI. BIRDS

Of all the native animals undoubtedly the Birds hold first place in popular favor and we have had more resident observers of birds than of any other group. A very large body of records has been compiled and is now in course of being published by the Geological Survey. The authors are the Messrs. Brimley and T. G. Pearson, formerly a resident of the state and member of our organization. The Volume will, we hope, be a fitting companion to the one on Fishes, already referred to. In this group, fairly complete data is at hand from four localities which well represent the chief sections of the state, they are: Beaufort, Raleigh, Chapel Hill and vicinity of Asheville. Tribute should here be paid to the pioneer work of Mr. C. W. Cairns (now deceased), of Weaverville. Working single-handed in his leisure hours, he made known a large part of the bird-life of the Asheville region, and made material contributions to what we know of other groups in that section.

But even in this relatively well-known group we find some curious and awkward gaps in our definitely recorded data. Thus, Currituck County has a record of 37 species of water-fowl and shore birds, but the Sharp-shinned Hawk is the only land bird on positive record. Another case in point is found in the group of owls. The Barred Owl is probably our most common and widely distributed owl, but has found its way into our records of only four localities, while the Barn Owl, which is one of our least common owls is recorded from no less than thirteen distinct localities. As with many other things the explanation is easy when you know it. The Barred Owl is not especially conspicuous and creates no striking impression when seen, hence the hundreds that are doubtless killed every year excite no curiosity and only the bird student who is interested in placing every species on exact record, takes actual note of its presence. But the much scarcer Barn Owl, is of striking and ludicrous appearance, and so seldom seen that when one is captured the captor is apt to think that he has discovered a new species of bird, and

not infrequently gets his name in the local paper with a sufficiently accurate description of the bird, so that it can be positively recorded.

In this connection I may call your attention to two more interesting facts brought to light in the study of our bird fauna. Until about 1900 the Song Sparrow, which is a delightful singer and a favorite in regions where it nests, was known in this state only as a winter resident, leaving for the north at the approach of the nesting season. Neither Cairns, or other very competent observers ever recorded it as nesting in our mountains, though their observations were comprehensive and reliable. We have every reason to believe that this fine little bird did not stay in our state at all through the summer during that period of time. But about 1900 records of its occurrence in our mountains in summer began to creep in, and in 1908 Mr .C. S. Brimley and the speaker confirmed its presence during the nesting season in a number of our mountain localities and data has since accumulated to show that it is now one of our commonest nesting birds throughout our mountain region. Another interesting fact is that in 1908 observations showed that the pestiferous English-sparrow was not established in the town of Highlands (Macon County) and the most common bird of the street and door-yards was the native Carolina Junco or "snow bird".

It is an interesting fact that Raleigh and Asheville (vicinity) which are the two best studied localities, have exactly the same number of species (207) on record. In water and shore birds, Raleigh has the greater number by three, while with the land birds the case is reversed. Only three other localities, namely Beaufort, Havelock and Chapel Hill, have over 100 species on record. Reasonably creditable records are available from Pea Island, Durham, Highlands, and Andrews, and material contributions have come from quite a number of other localities.

Merely to observe and record the birds seen, is not especially difficult, for even an amateur can soon become fairly proficient in recognizing the species, but to obtain exact data on migrations, especially the fall migrations to the southward, and on the regions where each species nests, is far more difficult. Hence

although much data has been secured from many persons in many localities, much of the more detailed work still remains unfinished.

VII. MAMMALS

This is the only group in which any considerable reliance can be placed on common report, and even here it must be accepted with discrimination. If one can secure the positive statement from a reputable resident, that deer or bear occur in that locality the record can be accepted because the species are distinctive and cannot possibly be confused with other kinds. But when it comes to recording the different species of smaller mammals, like mice and bats, only careful collecting will reveal the truth. In addition to what is known of the marine mammals of our coast, the land forms occurring at Raleigh and Asheville are quite well known, 36 at Raleigh and 27 at Asheville. From 15 to 20 species are known from Bertie County in the east and Roan Mountain in the west. From 7 to 12 species are on record for eight other localities.

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Such is the condition of our recorded knowledge of the fauna of the state. I have not attempted to discuss the flora, though a study of it would be included in any attempt at comprehensive Biological Survey work, but I doubt not that in the flora as with the fauna, much is already known, with many equally important gaps in the record. Upon this point our botanical members may, if they wish, enlighten us at other times. But we know they have not been negligent in the study of our varied forms of plant life, and we may hope that their ambitions will not be satisfied until they thresh out the questions of occurrence and distribution upon a reasonably comprehensive scale.

The collection of such data as I have been attempting to discuss is what we may properly term Biological Survey work. I have attempted to show that it means more than the mere listing and description of species. Of equal or even greater importance is the mapping out of the regions where the species occur, and in the case of those whose activities are seasonal, of defining the seasons when their important activities are evident. The need of

this is obvious for all forms which are of immediate economic importance. It is also apparent for all that host of forms which have potential powers for good or evil, while with the many forms which for the present seem to be of no direct importance we need the same data not only to strengthen and complete the chain of information, but because we never can tell when some unsuspected relationship between them and our welfare may be discovered.

The accumulation of data of this kind and its publication, could but supplement and strengthen the work of those who are chiefly interested in the study of that other branch of biology,—morphology. And it would furnish a safer ground-work for such directly economic studies as the life-histories of destructive insects, the spread of weeds and of fungous diseases of plants. Closely allied to it would be studies on the interplay of biological forces; influence of parasites on host of birds and insects, of birds in spread of weeds, of insects on spread of plant and animal diseases, etc.

In state Biological Survey work, Illinois seems to be in the lead with a state Laboratory of Natural History established by law and supported by legislative appropriation since 1885.

Certainly for the present I do not believe that North Carolina could be expected to appropriate of its public funds for work of this kind, but I cherish the hope that those of our institutions and individuals who are interested in biological work, may find some way to so correlate their efforts that more help may be given from one to another. Might we not hope by such an united effort to prepare and publish, as time goes on, volumes on the other groups of animals, as has already been done for the fishes? Can we not hope for similar work on the plants? The question of means for publication may appear serious, but the speaker is persuaded that when any worker or body of workers has secured and carefully assembled the data, that some means of publication and of illustration also, can be found. Our Geological Survey has made a splendid start in this, and surely some way can be found for its continuance.

During the past year, in Ohio, some twelve or more educational institutions have united their efforts to establish the

work of a State Biological Survey in which all may take part and share in the benefits of the data and material collected. This plan had its origin in the Ohio Academy of Science. From the introduction to the first Bulletin of the Ohio Biological Survey the following is quoted:

"The object of the Survey will be to secure accurate and detailed information as to the occurrence, distribution and ecology of the animals and plants of Ohio, for the benefit of the people in general and particularly for those engaged in school instruction, and to collect, identify and distribute material that may be of service in educational work."

"The co-operative board is planned to consist of a representative from each institution and organization agreeing to the plan of co-operation and contributing a membership fee of $25.00, such representative to be appointed by the executive officer in the institution or organization."

It seems to me that some similar method might be adopted by interested institutions in our state, making provision also for individuals who are not connected with institutions. Additional funds might be needed as the work progressed, but some correlation of effort and interest would seem to be the first essential step.

Notice that the Ohio plan involves the idea of making this work of benefit not only to the workers themselves, but also to "the people in general." This implies a popularization of the knowledge acquired by the Survey. In our own state I do not think the conditions were ever better nor the need more urgent for the popularization of all kinds of scientific knowledge than at present. Witness the extension work of our Agricultural College and State University, and the farm demonstration work conducted from Washington. North Carolina is still essentially a rural state. We have no large cities. Any able-bodied citizen can in a half hour walk from his residence into the woods and fields where Nature's innumerable forms of life surround him on every side. Man is himself an animal and derives his physical sustenance from Nature's substances, hence I am much inclined to accept the remark I once heard from the lips of a distinguished zoologist to the effect that "every person is by nature a potential naturalist." Mr. Brimley tells me that in England a much larger proportion of the birds, flowers, and

insects are called by familiar names by country children, than is the case here. In America we have thus far tended less toward the popular study of scientific subjects and this is to be regretted. We need all over the state a popular awakening to the beauty, variety and importance of the forms of life around us. We need students who shall know our animals and who can instill an interest in them into the lay mind. We need other students to do the same for our flora. Both furnish delightful fields for recreation among persons who may be ordinarily engaged in commercial pursuits.

What has thus far been accomplished in making known our plant and animal life has been done chiefly out of pure fondness for the subject itself, the material and data being gathered quite incidental to the performance of other duties. The accumulation of the data which I have here attempted to summarize, has been going on for many years. And if perchance it should seem to anyone that it is extensive, we may humble ourselves by remembering that what little is now known is but a meagre suggestion of what yet remains to be learned.

RALEIGH, N. C.

THE OCCURRENCE AND UTILIZATION OF CERTAIN MINERAL RESOURCES OF THE SOUTHERN STATES.

(*Continued from June Number*)

By Joseph Hyde Pratt.

PLATINUM.

A very systematic search has been made throughout a number of the Southern States for platinum and grains of platinum have been reported to have been found in the sands from placer gold washings in Rutherford and Burke counties, North Carolina [1]. Mr. W. E. Hidden made a very thorough search for platinum at these reported localities but failed to discover any, and the present writer has examined very carefully many of the reported localities without having discovered any native platinum. This metal has also been reported from a number of localities in Georgia but they are no more authentic than those of North Carolina. Mr. Hidden said in regard to his exploration for platinum in the South: "I will state that at the many places where I operated I did not succeed in finding any traces of its existence." The southern states of Virginia, North Carolina, Georgia and Kentucky have always attracted considerable interest from those who have been searching for platinum inasmuch as in these states are found large deposits of peridotite and serpentine, associated with which is more or less chromite. In many parts of the world where platinum has been found in alluvial deposits, it has been associated with chromite and serpentine. It has also been found directly associated with chromite, and as chromite originated in the serpentine, or rather in the primary rock, peridotite, it would seem to indicate that the original source of the platinum was also the peridotite or an allied igneous rock. Although no platinum has yet been found associated with these rocks in the South, it is not unreasonable to expect that some day it will be found [2].

[1] U. S. Geol. Survey, Bull. 74, 1891, p. 14.
[2] Pratt and Lewis: N. C. Geol. Survey, vol. 1, 1905, p. 373.

Platinum in the form of arsenide ($PtAs_2$), known as a mineral sperrylite, has been found very sparingly at the ruby mines in Cowee Valley, Macon County, North Carolina.[3]

PRECIOUS STONES.

The production of precious stones has never been very large in the Southern States but these states have produced some of the most unique and exquisite gems that have been found in the United States. Two of these gems, hiddenite[4] and rhodolite[5] were first identified in North Carolina and thus far have not been found in any other State. The first of these was discovered in 1881, at Hiddenite, Alexander County, and ranks near the diamond in price on account of its great rarity. The rhodolite was discovered in 1895 on Masons Branch of Cowee Creek, and has been quite extensively mined. North Carolina, Kentucky and Arkansas have been favorite fields of exploration for the diamond as all three of these states contain a rock that is very similar to the rock in which the diamonds are found in South Africa. Diamonds have been fonud in Virginia, North Carolina, South Carolina, and Georgia in placer mining, but none have thus far been found in place. Very recently, diamonds have been found in Arkansas and the locality seems to give promise of developing into a genuine deposit of these gems. The Southern States of Virginia, North Carolina, and Georgia have produced some of the finest amethysts that are on the market, and North Carolina has produced some of the most beautiful blue and golden beryls that have been found in the United States. Two other gems that have attracted a great deal of attention in the Southern States are the ruby and sapphire. As has been stated above, corundum occurs quite abundantly in the Southern States and in a great many of the mines blue and red corundum were discovered. This caused considerable interest in these deposits as a probable source of the ruby and sapphire, and although in many of these mines a few sapphires and an occa-

[3] Am. Jour. Sci. Vol. V, pp. 294-296.
[4] Am. Jour. Sci. *Ibid.*
[5] Am. Jour. Sci. *Ibid.*

sional ruby were found, none of them produced a great amount of material. A ruby deposit, however, was discovered in 1893, in Cowee Valley, Macon County, North Carolina, that has produced some remarkably fine rubies equal in color and lustre to any of the Burma stones. Although these ruby deposits have been developed for a great many years, only a very small amount of material obtained has thus far found its way on the market.

COMMERCIAL MINERALS ASSOCIATED WITH PEGMATITE.[6]

Many of the minerals that were assigned to the author for discussion are associated with pegmatite. The mining of some of these has not proved profitable until some of the associated minerals could be produced and marketed. From some of the pegmatitic dikes in the Southern States several minerals are now being mined. Mica stands out prominently as the principal mineral obtained from these dikes, with kaolin a close second. The potash feldspars, which occur quite abundantly in some localities, have only recently been mined on account of their former distance from the railroad.

These pegmatites are not all of the same origin, some being true dikes of igneous origin and others having an aqueo-igneous origin. I shall not try to take up here any discussion regarding the origin of the pegmatites.

The three principal minerals of the pegmatitic dikes are quartz, feldspar, and muscovite mica, and these probably constitute about 95 to 99 per cent. of the dike. Besides these, there are a large number of minerals that have been found in these dikes, some occurring sparingly and others abundantly. There is given below a list of those minerals that are known to have been found in the pegmatitic dikes of the Southern States, and those which have been obtained in sufficient quantity to be of value commercially are marked with an asterisk.

LIST OF MINERALS FOUND IN THE PEGMATITIC DIKES OF THE SOUTHERN STATES

Actinolite
Albite* (Feldspar)

[6] N. C. Geol. Survey. Economic Paper 3, 1900 p. U. S. Geol. Survey Min. Res.

Allanite
Almandite* (Garnet)
Andradite (Garnet)
Apatite
Auerlite*
Autunite

Beryl* (emerald, yellow, blue and aquamarine)
Biotite* (Mica)
Brookite

Cassiterite*
Chabazite
Columbite*
Corundum*
Cyanite

Enstatite
Epidote
Eucryptite

Feldspar { Albite*, Oligoclase*, Orthoclase*, Microline* }
Fergusonite
Fluorite

Gadolinite*
Garnet { Almandite, Andradite, Pyrope, Spessartite }
Graphite
Gummite* (Uranium mineral)

Hatchettolite
Hematite
Hiddenite (var. of Spodumene)
Hyalite (var. of Opal)

Ilmenite (Menaccanite)
Iolite

Kaolin*

Limonite

Magnetite
Menaccanite (Ilmenite)
Mica { Biotite*, Muscovite* }
Microline (Feldspar)
Microlite
Molybdenite
Monazite*
Muscovite* (Mica)

Nivenite

Oligoclase* (Feldspar)
Opal (var. Hyalite)
Orthoclase* (Feldspar)

Phosphuranytile (Uranium mineral)
Pyrite
Pyrope (Garnet)
Pyrophyllite
Pyrrhotite

Quartz* (Massive, crystallized and smoky)

Rogersite
Rutile

Samarskite*
Spessartite (Garnet)
Sphene (Titanite)
Spodumene* (var. Hiddenite)

Tantalite
Thulite (var. of Zoisite)
Titanite (Sphene)
Topaz
Tourmaline (Black)

Uraninite*

Uranium Minerals { Gummite, Phosphuranytile, Uraninite, Uranotil }

Uranotil

Xenotime

Yttrialite

Zircon*
Zoisite (var. Thulite)

A number of the minerals in the above list are described below in considerable detail while others are but briefly mentioned.

KAOLIN, FELDSPAR AND QUARTZ.

One of the alteration products of the feldspar of the pegmatitic dikes is kaolin. Some of the finest kaolin produced in the United States is obtained from the decomposed pegmatites in North Carolina, South Carolina and Georgia. These kaolins usually burn to pure white and are used in the manufacture of some of the finest china ware, enameled brick, etc.

In some of the dikes the feldspar is not altered at all and such dikes in Virginia, North Carolina, and Georgia are being

investigated for potash feldspar for use in the manufacture of pottery. Formerly this feldspar was too far from transportation to be profitably mined, but now since the railroads have penetrated into these districts, these deposits are available; and several are now being worked in North Carolina. These feldspars contain from 12 to 14 per cent. of potash.

Masses of quartz which are very pure are found in many of the pegmatitic dikes. It has two possible values: one for use in the manufacture of glass and the other in the manufacture of pottery. At the present time no quartz is being produced from these pegmatitic dikes for commercial purposes, but its prospective value is being investigated.

With these three raw products that are used in the manufacture of pottery—occurring abundantly in the Southern States—it is only a question of a little time when pottery manufacturing plants will be established somewhere in the South, and we will stop shipping all our raw products north and buying them back again in various forms of clay manufactured products, thus paying double freight rates. In the vicinity of many of the pegmatitic dikes are water powers which would be available for grinding the quartz or feldspar in preparation for use in pottery works.

RARE EARTH MINERALS.

Several of the rare earth minerals have been found associated with the pegmatites in the Southern States in commercial quantity. A commercial demand having arisen for certain chemical elements or compounds, mineralogical investigations were begun to determine a probable source of these elements, and in many instances the minerals containing them have been discovered in the South. Many of these elements have been required for use in the manufacture of certain lighting apparatus, as thoria in the manufacture of the mantles for the incandescent lamps; zirconia and yttria in the manufacture of the glower for the Nernst lamp; tantalum for use in the electric bulb; uranium (only experimentally) in the electric bulb; and tungsten in the manufacture of the tungsten electric bulb. With the exception of tungsten, minerals contain-

ing all the other elements have been found in commercial quantity in the Southern States. Monazite, a source of thoria, and zircon, a source of zirconia, are described in considerable detail beyond.

Uranium Minerals:—At several of the pegmatitic dikes in Mitchell and Yancey counties, North Carolina, the uranium mineral, uraninite and gummite, one of its alteration products, have been found in some quantity The amount of these minerals found in the pegmatitic dikes does not warrant mining for them only, but as a by-product in mica mining they will add considerably to the profit of the mine. It is of interest to know that the uraninite obtained from the Flat Rock mine, near Spruce Pine, Mitchell County, has shown the highest radioactivity of any uranium mineral thus far found.

Samarskite:—This mineral is one of the more abundant minerals containing the rare earth oxides, and large quantities of it have been found at the Wiseman mica mine in Mitchell County, North Carolina It is essentially a niobate and tantalate of iron and calcium with the cerium and yttrium metals, together with uranium oxide The yttrium oxides vary from 6 to 15 per cent., and the cerium oxides from about 2 to 6 per cent. The color of samarskite is velvet black, and its lustre varies from vitreous to resinous and splendent. It is commonly found massive or in flattened embedded grains, but occasionally in fairly well-developed prismatic rhombohedral crystals. Its usual occurrence is in pegmatitic dikes, and at the Wiseman mica mine, it has been found in masses over 20 pounds in weight. At other mica mines in North Carolina it has been found more sparingly.

Tantalum Minerals:—Columbite and tantalite, the two minerals that contain tantalum, are found to some extent in the pegmatites of the Southern States. Of these two the columbite is by far the commoner and occurs in greater abundance It has been found in some quantity near Amelia Court House, Amelia County, Virginia; the Wiseman and Deake mines, Mitchell County, and the Ray Mine, Yancey County, North Carolina; tantalite has been found in Yancey County, North Carolina, and Coosa County, Alabama. Thus far, how-

ever, there has been no mining of either of these minerals for commercial purposes.

MICA.

The first mica mining in the South was very evidently done by the Indians as old underground workings have been encountered, in some of which Indian implements have been found. That the Indians were attracted by the transparency of mica, probably for ornamental purposes, is shown by the old workings on mica veins that exist in western North Carolina. In a number of old workings which have been discovered and re-opened, stone Indian relics have been found. An interesting discovery has recently been made in Ohio in some of the old Indian mounds, which have been opened, of beads which closely resemble pearls. The outer covering of these beads is minute scales of a partially altered mica. As no mica occurs in Ohio, it must have been brought from some of the eastern states and perhaps from the mines of this section. Just what use the North Carolina Indians made of the mica they obtained is unknown, but as it could be readily cut and made into all sorts of shapes and was transparent, it would naturally attract the Indian.

The mining of mica for commercial purposes was first commenced in 1867, in North Carolina, and the mica obtained was superior to any mica that had ever been put on the market, and immediately became the standard mica by which other micas were judged. Since that date mica mining has been carried on in Virginia, North Carolina, South Carolina and Alabama, but with considerable variation in the production of the mineral. About 1885 there began the importation of mica (duty free) from India and a little later from Canada. This at once began to affect the Southern production, which continued to decrease until the McKinley tariff bill became effective in 1892-93, which placed a duty on mica. As one of the principal uses of mica was in stoves that were used for heating houses, there was a large falling off in the demand for the mineral with the decrease in the use of stoves for this purpose following the introduction of other methods for heating houses.

Up to this time there was no use made of the scrap mica nor for the small sheets, and it was not until about 1890 that a demand arose for the small sheets and punched mica for electrical apparatus. This demand for the waste mica together with the duty caused a revival of the mica industry of the South. A use was also found for scrap mica, to be used in manufacture of axle grease, wall paper, etc., which added greatly to the income of mica mining and greatly increased the production of the Southern mines. There has always been a strong competition between the Southern and the imported mica. The Southern mica was always able to easily compete with the foreign when there was a large demand for it for stoves, but with the smaller demand for this purpose and the much larger demand for use in electrical purposes, for which the foreign mica gives equal satisfaction with the Southern mica the competition has been greater, and often to the disadvantage of the Southern mica.

OCCURRENCE.

The muscovite represents the most common mica and is very widely distributed, being a component of many of the crystalline and sedimentary rocks. In many of these it occurs in but small scales or crystals which have no commercial value. When, however, it occurs in blocks or masses which can be split into sheets an inch or more in diameter, it has a commercial value which increases with the size of the cut sheets, and these vary from 1 by 1 to 8 by 10 inches. These commercial deposits of mica are found for the most part in pegmatitic dikes or veins, which occur as intrusives in granite and in hornblende and mica gneisses and schists, and have been mined in Virginia, North Carolina, South Carolina, Georgia and Alabama. These dikes or veins vary in thickness from a few inches to several hundred feet and are often very irregular, having arms or apophyses branching off from them and extending out into the country rock in many directions. Sometimes these dikes are parallel to the bedding or schistosity of the gneiss or schist, and then again they break across it at varying angles. Both of these phenomena are often observed in the same dike. The

principal mineral constituents of these dikes are quartz, feldspar, and muscovite mica, which occur in varying proportions. In examining these dikes it will be found that sometimes the quartz and feldspar are nearly equally distributed throughout a certain part of the vein, while in other parts sometimes one and again the other will predominate. Feldspar has been observed that has crystallized out in enormous masses of more than a ton in weight, and in one instance, at the Irby mine, near Spruce Pine, Mitchell County, North Carolina, a well-developed crystal of feldspar was observed that measured 3 by 11 1-2 feet. Occasionally feldspar, quartz, and mica have separated out in rather small masses, giving the vein the appearance of containing an equal quantity of each. In such cases the three minerals are so intimately associated with each other that the mica is of little or no commercial value and the feldspar is also of no commercial value. Judging from observations made at a great many mica mines the pegmatitic dikes that yield the best commercial mica are those in which the three minerals have had a tendency to crystallize out in large masses. Thus, where feldspar and quartz are in small crystals or fragments, the mica is also apt to be small. Those dikes that are two feet or less in width very seldom contain mica having any commercial value beyond what could be obtained for it as scrap mica, and hence little or no attention should be paid to such dikes as a source of mica. Not all of the wide dikes carry mica of the right quality or in sufficient quantity to afford profitable mining, for in some the mica has been observed to occur in such small crystals and blocks that no sheets could be obtained over an inch or two in diameter.

The muscovite mica occurs in these dikes usually in rough crystals (called blocks or books), which are sometimes distributed nearly evenly throughout the dike and at other times nearer the contact of the dike with the country rock. These blocks of mica are occasionally nearly perfect in their crystalline form, which is monoclinic, but imitating rhombic or hexagonal symmetry. The commercial blocks of mica usually vary in thickness from 6 to 18 inches and from 3 to 15 inches in diameter, although some blocks have been found as much as

4 feet in diameter and from 2 1-2 to 3 feet in thickness. All of the large blocks of mica are not of sufficient quality to cut into sheets as large as would be expected from the size of the crystal, on account of much of the mica having been converted into what is called "ruled mica", the mica being divided into narrow strips whose edges are parallel to the intersection of the prism and base edges of the crystal, or into "A" mica, in which the sheets are cut or striated parallel to two adjacent edges.

PERCENTAGE OF MICA IN THE DIKES.

There is considerable variation to be noted in the percentage of mica that occurs in these dikes and in different parts of the same dike. It is usually found, however, that in any considerable distance in the same dike the mica will average for that distance approximately the same per cent. It is seldom that the mica in a dike will average over 10 per cent. of the contents of the dike for any considerable distance, and it will sometimes average as low as 1 per cent. Portions of certain dikes have been observed that had the appearance of containing a very large percentage of mica on account of a number of blocks of mica being clustered together in bunches almost touching one another, while in other portions of the same dike there would be almost a complete absence of mica for a distance of from 5 to 20 feet; but even in such a dike the general average of the mica to the other minerals corresponded to about 10 per cent. The general limits of the percentage of mica in various dikes is probably, therefore, from 1 to 10 per cent.

Of the mica that is obtained in these dikes, there is probably an average of not over 10 to 15 per cent. that can be cut into sheet mica, the rest being waste or scrap mica. Selected masses or blocks of mica, however, have been mined that have averaged from 30 to 40 per cent. and occasionally as high as 75 per cent. of sheet or plate mica. On the other hand, there will be certain portions of the dike in which none of the mica mined can be cut into sheets or plates, and is all of value only as scrap mica. These variations have been observed where

they have taken place within the space of a few feet. As far as can be ascertained from observations in the field and from the results of mining, the North Carolina mines will average the highest percentage of cut mica of any in the United States.

There are a number of reasons for this large percentage of waste mica—the irregularity of the blocks of mica and of the individual sheets; the ruled mica and the "A" mica, which reduce the sizes of sheets that can be cut or prevent entirely any sheets being cut from the block; the mica may be specked or stained, or may contain a great deal of magnetite in thin crystallized films between the foliae of the mica; and many blocks of mica may be destroyed by having garnet, tourmaline, or quartz crystallized out between the foliae. It will be observed from what has been said that in mining mica there must necessarily be a very large amount of waste rock or gangue removed, and, as in nearly all mica mining it is necessary to operate by blasting, it makes the cost of production of the crude mica somewhat expensive. Hence, if any of the other minerals that must be removed in mining can be utilized commercially, they will make valuable by-products and will help to pay the cost of mining the mica.

One of these minerals, feldspar, has already become of commercial importance and is now being produced in North Carolina. Pure quartz, free from oxides that would discolor any glass made from it, occurs associated with the mica in many of the deposits, and investigations are now being made to determine the commercial value of this quartz as a source of raw material for the manufacture of glass.

The production of mica from the Southern States in recent years has been principally from North Carolina with much smaller amounts from Alabama and Virginia. North Carolina produces two-thirds of the value of the total production of mica in the United States.

Other minerals occurring in these pegmatitic dikes which are being mined for mica that will make valuable by-products are kaolin, uranium minerals, samarskite, beryl, and other gem minerals.

MONAZITE

The discovery that thoria would make a much better incandescent mantle for lighting purposes than zirconia made it necessary to discover commercial deposits of some mineral containing a considerable percentage of this compound. The mineral that offered the best chance of furnishing this salt was monazite, which had been discovered in 1879 by W. S. Hidden [7]. Prospecting was carried on quite vigorously for this mineral, chiefly in North Carolina, with the result that it was found in considerable quantity. Since this first discovery the North Carolina areas containing this mineral in quantity have been very largely extended and it has also been found in South Carolina.

The first commercial shipment of monazite was in 1887, and the production was continued each year until 1910, but since then no production.

Monazite also furnishes ceria (CeO), another salt that is used in very small amount in the manufacture of incandescent mantles; and is also used by pharmacists.

OCCURRENCE

Monazite is found very widely distributed as an accessory constituent in varying proportions of many granites and their derived gneisses. Thus it has been found in the porphyritic, granulitic, and schistose gneisses of the Maritime Mountains of Brazil, extending for a distance of 300 miles through the provinces of Bahia, Minas--Geraes, Rio de Janeiro, and Sao Paulo; and in the granitic mica-gneisses and hornblende-gneisses of the South Mountain region of North Carolina, covering an area of some 3,000 square miles in McDowell, Burke, Caldwell, Rutherford, Cleveland, Polk, Catawba, Iredell, Alexander, Lincoln, and Gaston counties, and extending into Spartanburg, Lawrence, Greenville, Pickens, Anderson, Oconee, South Carolina. Although occurring in but small quantity it has been identified in the granites or gneisses of Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York,

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[7] Am. Jour. Sci., (3) vol. 21, 1881, p. 159, and (3) vol. 32, 1886, p. 207.

North Carolina, South Carolina, and Georgia. In North Carolina there are a number of mica-schists that carry monazite, as that near the Deake mica mine, Mitchell County, and at Milholland's mill, Alexander County.

The rocks of this monazite area are for the most part gneisses, schists and granites. These vary considerably and are grouped under the following heads:

1. Carolina gneiss.[8]
2. Roan gneiss.[8]
3. Granites.
4. Pegmatites.

The Carolina gneiss is the oldest formation and is of Archean age. Its structure varies considerably, the more common types being mica, garnet, cyanite and graphite gneisses and schists. Associated with this Carolina to such an extent that it is a rather characteristic feature is pegmatite and, as will be seen later, this pegmatite is common throughout the portions of the area that carry monazite in commercial quantity.

The Roan gneiss, which is the next oldest formation in the monazite region, consists almost entirely of hornblende gneiss and schist. The granites of the area are gneissoid, porphyritic and massive in structure and while of uncertain age, they are probably Archean.

The pegmatite occurs in two distinct phases; one in which it forms distinct masses or bodies with the typical composition and texture of pegmatite, while the other phase is a pegmatized gneiss which represents the addition of the pegmatite minerals to the gneisses which has caused a partial recrystallization of portions of the gneiss. The structure of the pegmatite is irregular, occuring in some places in sheets or lenses interbedded and folded with the enclosing gneisses and schists, while in other places it occurs in dikes, veins or lenses either conformable with the enclosing rocks through part of its extent and cutting across them in other parts, or in irregular masses

[8] U. S. Geological Survey, Asheville Folio, No. 116, 1904; pp. 2 and 3.

having no definite orientation with respect to the accompanying formations. All the rocks in this area are more or less weathered and decomposed and a clue to the nature of the rock formations themselves is often obtained by a study of the character of the gravels in the bottom lands and streams draining a particular region. Thus, a very light colored gravel with quartz debris indicates a granite or a very highly pegmatized country rock. Garnet and hematite, with fragments of mica or cyanite gneiss, indicate Carolina gneiss. When quantities of black sands containing magnetite, ilmenite, hornblende, etc., are found in the stream gravels, it is an indication of the Roan gneiss. Monazite occurs for the most part in the pegmatized gneiss and schist bodies which are phases of the Carolina gneiss. The texture developed during the pegmatization is generally porphyritic and there may be a gradation from the porphyritic gneiss into more or less highly pegmatized gneiss and from this into regular pegmatite.

In those beds or portions of beds where there has been little pegmatization, there is but a small amount of monazite. It is also true that where pegmatization has been complete and but little of the original gneiss remains, there is but little monazite. The chief occurrences of the monazite are in those portions of the gneisses and schists which have been highly pegmatized and are rich in secondary quartz and contain numerous small masses of feldspar with some biotite, graphite and other accessory minerals. The monazite is nearly always well crystallized, although the crystals are extremely small. The percentage of the monazite in the rock is very small and will not average over .75 of one per cent. An attempt has been made to work the rock itself, but it was found impossible to do so at a profit on account of the low percentage of monazite.

The origin of the monazite in the pegmatized gneisses and schists was either by the bringing together of the elements necessary for its formation from the original rock during recrystallization, or by the introduction of these elements into the pegmatizing materials from external sources. This form of pegmatization is usually in close proximity to granite mas-

ses which gives evidence of its formation through magmatic agencies.

Associated with the Carolina and Roan gneisses of Madison County, North Carolina, about 4 1-2 miles southwest of Mars Hill, there is an unusual occurrence of monazite.

The principal country rocks of this area are Carolina and Roan gneiss and Cranberry granite.

In this particular vicinity the Carolina gneiss occurs as outliers from the main formation and is not interbanded with the Cranberry granite. Immediately to the east there is a large mass of Roan gneiss and this is also observed farther to the west. The Cranberry granite as it occurs in this vicinity is also in the form of outliers or apophyses from the main mass lying to the north and west. It is an igneous rock composed of quartz and orthoclase and plagioclase feldspar with biotite, muscovite, and, in places, hornblende as additional minerals. There are a number of accessory minerals as magnetite, ilmenite, garnet and epidote, found in this granite. This granite occasionally contains pegmatite areas and, on the Whiteoak Creek, a great deal of the gneiss and granite was pegmatized.

There are no extensive areas of rocks outcropping on this hillside. Occasionally small boulders of the partially decomposed granite were observed containing more or less epidote and ilmenite forming a sort of ledge running around a hill about a third of the way to the top. About 100 feet up the hillside a shaft has been sunk to a depth of 45 feet. The rocks were decomposed throughout this distance so that no blasting whatever was necessary. On account of the excessive decomposition of the rocks, it was difficult to determine what the rocks at this particular point were. They had the appearance, however, of being decomposed Cranberry granite. The section exposed by the shaft showed the rocks to be more or less pegmatized and to carry monazite the whole depth of the shaft. The monazite seemed to occur in the pegmatized band of the rock which, in the shaft as exposed, had a width of 2 1-2 to 4 feet and does not occur in any sense in a vein formation.

The monazite, which is of a clove brown color, was found in fragments or rough crystals varying from pieces the size of

a pea up to a large rough crystal that weighed almost exactly 60 pounds. No attempt was made at this time to determine the percentage of monazite that the rock would carry. One or two pans full of the monazite-bearing portion of the rock were dug out, which gave nearly a pound of monazite.

As stated above, the monazite is in the form of irregular fragments, rough crystals and cleavable masses. One of the best crystals observed was a part of a mass that weighed 6 1-2 pounds, which was made up of crystals in parallel position with some of the facies very perfectly developed. Another crystal, which was well terminated, weighed 12 ounces. It was 2 3-4 inches long in the direction of the *b* axis and 1 1-2 inches in the direction of the *a* axis and 2 1-4 inches long in the direction of the *c* axis. The prismatic facies of the *a* pinacoid were well developed as was also the unit pyramid *w*. The lower end of the crystal showed no terminations. The facies observed on these crystals were indentified by means of the contact goniometer and were as follows: *a* (100); *m* (011); *w* (101); *v* (111).

The basal plane *c* was not observed on any of the crystals but was observed as one of the parting or cleavage planes. Parting planes were also very prominently developed parallel to *m*.

The masses of monazite were very pure and one analysis made to determine the percentage of monazite in the masses showed it to contain 99.5 per cent. monazite. No chemical analyses have been made of the mineral beyond the determination of the thoria. This determination, which was made in the laboratory of the Welsbach Light Company, showed this monazite to contain 5.06 per cent. thoria, which is equal to the percentage of thoria in the best commercial monazite found in the South Mountain region.

The size of the crystals of monazite found in this deposit and the possibility of its developing into an occurrence of commercial value make the discovery a most interesting one.

With any new or increasing demand for Carolina monazite, this property will undoubtedly be further developed with a good prospect of its becoming a commercial source of thoria.

During the past three years the monazite industry of the

Southern States has practically ceased. In 1905 there was 1,-350,000 pounds of monazite produced in the Carolinas, but in the past few years it has dropped to hardly 10,000 pounds.

ZIRCON

Zircon is commonly found sparingly in the crystalline rocks, especially gneisses, syenites, granites, in granular limestones, and in chloritic and other schists. Occasionally it is found associated with some of the iron ores. Occurrences of this mineral in quantity are not common, and there is but one locality in the United States where it has thus far been found in commercial quantity and that is in the vicinity of Zirconia, Henderson County, North Carolina. The zircons occur in a pegmatitic dike which is about 100 feet wide and has a strike of N. 50° E. It cuts up through the pre-Cambrian gneisses, and can be traced for a distance of about 1 1-2 miles. The upper portions of the pegmatitic dikes are badly decomposed and kaolinized to a depth of 40 feet or more. The zircons occurring in these dikes are of a grayish color and well crystallized, prismatic crystals terminated by the unit pyramid predominating. They occur for the most part in the feldspar, and where this is kaolinized it permits of an easy separation of the zircon crystals by hydraulic processes. As the feldspar becomes more solid and unaltered, the separation of the zircon is more difficult. In crushing the feldspar, however, the zircons readily free themselves from the gangue.

There are two deposits of these zircon crystals that have been worked; one near the southwestern end of the dike, which is known as the Freeman mine, and the other near the northeast end, which is known as the Jones mine. Owing to the slight demand for this mineral, there has been but little systematic mining carried on. Men and children are paid a certain price per pound for the zircon crystals, some of which they wash out of the soil, others out of the kaolinized gangue, and still others they break out by hand from the harder feldspar. The resultant product contains practically 100 per cent. of zircon.

The discovery of this commercial deposit, which was later developed as the Jones and Freeman mines, located near Zir-

conia, a station on the Southern Railroad, was largely due to the efforts of Mr. W. E. Hidden. Zircon was first discovered here in 1869 but no special importance was attached to it; and the first shipment was in 1888. Although the shipments of the zircon from this locality were never very large, yet they supplied the necessary material for use in the manufacture of the mantles for incandescent lights. Experiments regarding the most suitable material for the manufacture of these mantles were continued in the laboratories of the different companies, and in a few years it was discovered that thoria made a better mantle than zirconia, and therefore the demand for zircon began to decrease, until finally its production entirely ceased.

A new use, however, arose for zirconia—to be used in the manufacture of the glower of the Nernst electric lamp, and in 1902, mining for zircon on a small scale was again commenced at the Jones mine and has continued to the present time. In 1911 the Freeman mine, adjoining the Jones mine, also became a producer.

Associated with the zircon in these mines is auerlite [9], a mineral that contains approximately 70 per cent. of thorium oxide. It has been considered a hydrous silico-phosphate of thorium.

A special search will be made for auerlite while mining for zircon, and several kilograms have already been obtained.

Near New Sterling, Iredell County, a great many brownish, pyramidal crystals of zircon have been found in the soil, some of which were 1 to 3 inches in diameter. One crystal weighed about 6 ounces. The exact occurrence of these crystals has not as yet been definitely determined, but thus far there has been observed no indication of a commercial quantity.

There are small quantities of zircon found in all the monazite sands, which could probably be saved as a by-product. These crystals are very minute, and are transparent.

Gadolinite [10]:—There is also used in the manufacture of the glower for the Nernst lamp, yttria, which is found in some

[9] Am. Jour. Sci., III, vol. XXXVI, 1888, p. 46.
[10] U. S. Geol. Survey, Mineral Resources, pt. II, 1911, p. 1195.

quantity in the mineral gadolinite. This is another rare mineral, but the commercial demand for it was met by its discovery in quantity near Llano, Llano County, Texas.

TIN [11]

Tin ore in the form of cassiterite has been found in Virginia, North Carolina, South Carolina and Texas.

What may be called the Carolina tin belt extends from Gaffney, Cherokee County, South Carolina, in a general northeasterly direction across this county; the southeastern corner of Cleveland County, North Carolina, and across Gaston and Lincoln counties, North Carolina. The tin deposits found in Rockbridge County, Virginia, may be a continuation of the Carolina tin belt across Catawba, Iredell, Yadkin and Surry counties, North Carolina. The general direction of the rocks carrying the tin ore is the same as that in Virginia, and the continuation of this direction from the Carolina deposits would approximately cross those places in Rockbridge County, Virginia, where tin ore has been found. The same rocks that are outcropping in Surry County, North Carolina, are also in this same line and have the same general direction. The principal locality in South Carolina where tin ore has been found is about one mile north of Gaffney on land which belonged to Captain S. S. Ross. For a distance of 13 miles from a point about a mile northeast of the Ross mine no tin minerals have as yet been found. The next place in the belt where tin is known to occur is a short distance northeast of Grover, North Carolina, a station on the Southern Railroad. From this point tin ore has been found almost continuously for over 14 miles to within a few miles of Lincolnton. No tin has thus far been found in North Carolina northeast of the Lincolnton locality, nor in Virginia until the Rockbridge County deposits are reached.

The section of North Carolina and South Carolina in which the tin belt occurs is close to the border of the large area of Archean gneisses which extend over a large portion of the west-

[11] N. C. Geological Survey Bull. 19, 1904 pp.

ern part of North Carolina and the northwestern portion of South Carolina. Bordering these gneisses on the east, there is a series of granites and other igneous rocks extending from Cherokee County, South Carolina, across Mecklenburg, Cabarrus, Rowan, Davidson, Guilford, Caswell and Person counties, North Carolina, which have a general north to northeast direction. At the extreme southern portion of North Carolina, and extending into South Carolina, there is between these granites and gneisses a band of metamorphic rocks consisting of slates, schists, limestones, quartzites, and conglomerates whose age is unknown. These occur quite extensively developed in Cherokee County, South Carolina, and in Gaston, Lincoln and Catawba counties, North Carolina, and extend for a very short distance into Iredell County, North Carolina. No more of these rocks are observed in this northeast direction until they again outcrop in the northeastern portion of Yadkin County, extending nearly across Stokes County and almost to the Virginia line. They are in every way identical with those found further South and represent the same geological formation. Penetrating up into these rocks in Gaston and Lincoln counties, North Carolina, there is a mass of granite which is from five to ten miles wide. The schists vary considerably in character, sometimes being very siliceous and having a gneissoid structure. The general strike of these metamorphic rocks is northeast; and it is in this belt of rocks in North Carolina that the tin ore is found. The general strike of the pegmatitic dikes and veins carrying the tin is approximately the same as that of the metamorphic rocks, N. 25° E., but near the South Carolina line there is a rather sharp bend to the westward, so that from there to Gaffney, South Carolina, the direction of the tin belt is about N. 55° E., and it leaves the schists to the east and passes through the Archean gneisses. The rocks in the vicinity of Gaffney, South Carolina, are almost entirely gneisses, similar to those found in North Carolina to the west of the metamorphic rocks and which have been referred to as the Archean. There are, then, rocks of two distinct geological periods in which the tin veins have been found: (1) Those associated with the Archean gneisses, which are found

in the vicinity of Gaffney, South Carolina; and (2) those associated with the schists, which are of a later period, and with which most of the North Carolina tin is found. The ore at the Jones mine, 7 miles northeast of King's Mountain, is in greisen veins that occur in a gneissic rock, which may be a portion of the Archean gneisses to the west.

As has been stated above, the main country rocks are for the most part crystalline schists and gneisses, the former being micaceous, chloritic and argillaceous, and the latter micaceous and hornblendic. The strike of the schistosity of these rocks is usually in a general northeast direction and they dip for the most part at very steep angles to the westward. The veins in the gneisses are dipping toward the east at very steep angles.

The King's Mountain region of North Carolina is geologically situated in a band of metamorphic rocks composed of slates, schists, limestones, quartzites and conglomerates whose age up to the present time has not been definitely determined. The width of this belt near King's Mountain is about 10 miles and extends in a direction about N. 10° to 20° E. Just east of Lincolnton, Lincoln County, it joins another band of similar rock, the two being separated east of King's Mountain by a mass of granite. To the west of these metamorphic rocks are the Archean gneisses, with which the tin veins of Gaffney, South Carolina, are associated. The strata of these metamorphic rocks are tilted at very high angles to nearly vertical, and in the resultant alteration and erosion to which they have been subjected, the quartzites have resisted these influences the most, so that they now form the top of the peaks and ridges such as King's, Crowders and Anderson mountains, which rise 500 to 1,000 feet above the average elevation. It is undoubtedly the mass of granite which is to the east that has tilted these metamorphic rocks and thrown them into their present position.

There are a number of amphibole dikes that have been observed cutting these metamorphic rocks, but they have made very little change in the position of the schists through which they penetrated beyond a metamorphic action. These sedimentary rocks were tilted into their present position before the intrusion of these dikes, which are following partly the lamina-

tion of the schists and their general trend; but in a few instances are cutting across the schist. In two or three instances where these dikes are cutting across the schists, there are approximately parallel to them veins of tin ore. Pegmatitic dikes are also common throughout this belt of metamorphic rocks in North Carolina and in the gneisses further to the west in South Carolina. They could be followed almost continuously from three miles above Grover, North Carolina, to the Jones mine, 7 miles northeast of King's Mountain. In one place, a short distance below King's Mountain, North Carolina, the pegmatitic dike was all of 200 feet wide. They follow in many cases the planes of lamination of the schist which represent lines of least resistance. Where the pegmatitic dikes are cutting across the schists, they may be following old fractures that were produced at the time of the intrusion of the amphibole dikes.

About one-half mile below King's Mountain the pegmatitic rocks begin to outcrop very boldly and continue in this way nearly to Grover, North Carolina, a distance of 7 miles. This mass of pegmatite varies a good deal in width in this distance, from twenty-five to six hundred feet. Just in the northern edges of the town of King's Mountain there is another strong outcrop of the pegmatite, but from this point there is but little seen of the pegmatite northeast until Ramseur's mill is reached. Here the pegmatite has a width of about 200 feet.

A cross-section of the tin belt in the vicinity of King's Mountain would show the following sequence: hornblende-gneiss on the western boundary, followed on the east by schists which are in many places very badly decomposed; then a narrow bed of limestone, which is more or less siliceous; then quartzite; another bed of limestone; quartzite; schist; to the granite on the extreme eastern portion of the belt, having a total width of about 10 miles.

Perhaps the most extensive development work has been carried on near Lincolnton, Lincoln County, by the Piedmont Tin Mining Company. The property of this company, begins about 2 miles southwest of Lincolnton and extends in a general southwest direction for 2 miles, to the Little Catawba River, about midway between Long Shoal and South Side, two stations on

the Carolina and Northwestern Railroad. Tin-bearing pegmatite has been exposed at a number of places throughout this area, and has shown the existence of two or more approximately parallel pegmatitic dikes, which are also following the laminations of the schists and gneisses. There were other pegmatitic dikes also observed that were cutting the dikes referred to above and the lamination of the country rock. The company has acquired by purchase and lease control of a property about 2 miles long and 1 mile wide, which has been prospected more or less over its entire area.

The country rock of this section consists of hornblende and mica gneisses and schists that are intersected by the pegmatitic dikes, which sometimes are cutting across the strike of the schists and then again following it and at other times have sent off apophyses which have forced their way between the laminations of the schist and gneiss. Occasionally, a mass of the pegmatite is encountered that has all the appearance of a boss. These dikes are very variable in width from a few feet up to 30 or more. They have the usual mineralogical character of ordinary pegmatitic dikes, except that for the most part they are tin-bearing. The position of the tin in these dikes was carefully noted, and in nearly all cases it was observed that the main portion of the dike carried little or no cassiterite (tin oxide), but that this mineral was confined to restricted portions of the dike, which, in nearly all cases, was near the contact, of the pegmatitic dike and country rock. In these areas there was usually but little feldspar, and the dike was made up largely of quartz and mica. Occasionally, where the pegmatitic dike was narrow, tin oxide was found scattered sparingly throughout the whole mass.

The work done by this company has made this section the most favorable one for studying the occurences of these pegmatitic dikes and of the tin mineral which they contain. Beginning at the southwest end of the property, on a hill, just above the Little Catawba River, the company has sunk shafts and pits and made open cuts at various intervals from this point for a distance of 2 miles in a northeast direction to what is known as the Main Shaft mine, where the greater amount of

underground work has been done. Wherever any pegmatitic dikes have been encountered in this prospecting, they have contained more or less tin oxide, but in very varying percentages. The work has also shown that the pegmatitic dikes are extremely variable in width, both on the strike and dip. There are two points, one known as the Henry shaft and the other the Main shaft, where considerable underground work has been done.

It is the author's idea regarding the origin of the tin ore found in the Carolina belt, that it is due principally to the direct separation or recrystallization of the cassiterite from the molten pegmatite magma, with perhaps a little also due to a fumarole action, resulting from the escaping vapors during the crystallization of the molten magma of pegmatite intruded into the schists and gneisses in the form of dikes, which in turn had been subjected to the same reactions as the main mass of pegmatite.

None of the Southern tin deposits have thus far proved to be profitable producers of tin ore, although several tons of tin concentrates have been shipped from the Ross mine in South Carolina and from the mines in the vicinity of King's Mountain, and Lincolnton, North Carolina. The Lincolnton deposits referred to above have been developed to the greatest extent and have offered the greatest probability of developing a commercial source of tin. A large proportion of the pegmatitic dike which carries the tin has been decomposed and the feldspar been changed to kaolin. There is a possibility of this property becoming a producer of kaolin with the tin ore as a by-product.

Virginia:—The occurrence of tin in Virginia was described by Mr. Arthur Winslow in 1885, and later by Mr. Titus Ulke in 1893. This tin area extends along the eastern edge of Rockbridge County in the line of the Blue Ridge Mountains from a few miles north of the James River Gap to about the north line of the county. Cassiterite has been found at a number of places in this area, but the greatest amount of ore was found along the upper waters of Irish Creek in the northeastern corner of the county. There is one property that has been developed to some extent, and this is known as the Cash mine.

The greisen veins in which the tin occurs traverse the granite in all directions and are dipping at very steep angles. The width of these veins is usually from 8 to 12 inches, though some were observed that were several feet in thickness. The cassiterite is occasionally concentrated into seams from 1 to 2 inches wide and is associated with pyrite and arsenopyrite, the rest of the gangue of the veins being composed of quartz and mica. The principal work was done here about twenty years ago, and a concentrating mill was erected on the property and about 290 tons of rock were tested. It is reported that about 2,400 pounds of tin concentrates were shipped to Boston, but that they only averaged about 43 per cent. of metallic tin, due to the concentrates being contaminated with arsenopyrite and ilmenite. There was not sufficient work done on the property to definitely determine whether or not there existed a commercial deposit of cassiterite.

Texas:—Cassiterite has been found in Texas on the east flank of the Franklin Mountains, the southern extension of the Organ or San Andreas Range, about 10 miles north of El Paso. These deposits were discovered in 1899 and had been prospected to a depth of about 50 feet. The ore occurs in well-defined veins, which have a strike approximately east and west, which is nearly at right angles to the direction of the range and are dipping toward the north at very steep angles. There have been three veins discovered here, which have been exposed by pits and open cuts for several hundred feet along the strike. The veins occur in the granite and are considered by Mr. W. H. Weed to be the result of deep-seated agencies and that further exploration will develop well-defined tin veins.

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RECENT CONCEPTIONS OF THE ATOM

BY F. P. VENABLE

The original conception of the atom arose from the discussion among the early Greek thinkers as to the indefinite divisibility or ultimate indivisibility of matter. They were divided into two schools of thought—the plenists and anti-plenists, or vacuists. It was the belief of the latter school that all matter was composed of indivisible particles or atoms, and vacua.

These atoms are not mathematical points but are too small to impress themselves upon the senses and are indivisible. They differ in size, shape and weight; are in continuous motion (hence the necessity for voids); and are endowed with some inclination or force which causes them to meet in a selective way and by their union form the various kinds of matter known to us. This theory was the high achievement of pure reasoning with little basis of experimental evidence. We accept the atoms but for the vacua substitute the very original conception of Aristotle of a *quinta essentia* or ether, of whose existence we still have no tangible proof.

Through the centuries this theory of atoms has come down to us without important change or experimental support until Dalton made use of it to explain the great underlying laws of chemistry and attempted for the first time to determine the relative weights of these ultimate particles or atoms.

Dalton's conception of the atom becomes of greater interest in view of the modern speculations. In his New System of Chemical Philosophy (p. 147) he writes: "A vessel full of any

pure elastic fluid presents to the imagination a picture like one full of small shot. The globules are all of the same size, but the particles of the fluid differ from those of the shot in that they are constituted of an exceedingly small central atom of solid matter, which is surrounded by an atmosphere of heat, of great density next the atoms but gradually growing rarer according to some power of the distance: whereas those of the shot are globules uniformly hard throughout and surrounded with atmospheres of heat of no comparative magnitude."

How stubbornly the notion of the material nature of heat was held to may be realized from an examination of Lavoisier's explanation of the expansion and contraction of matter and from the fact that it was included by some in the list of elements for years after the time of Dalton.

According to Dalton's hypothesis these atoms of definite and distinctive weight combined under certain fundamental laws to form the various substances that make up the material world. As to the size and form, the chemist gave himself no concern, but took up the task of finding out the exact, relative weight of every different atom known to him. These atoms he believed to be unchangeable and thus made possible a mathematical basis for his science.

But the physicist is necessarily concerned with the atom also, and at the same time that Dalton reaffirmed the atomic theory, Young gave his reasons for regarding the atom as a perfect elastic sphere in the place of the conceptions that had grown up of mathematical points, various other geometric forms and rigid particles.

The Daltonian atomic theory was slow of acceptance because of the confusion arising between the divisible ultimate particles of compounds and those which so far as was known were undecomposable. A clear distinction had to be drawn between atom and molecule and this was not easy until many facts had been accumulated. Chemists came to know many different kinds of atoms representing as many different elements. These elements were at first called simple bodies, but to accurately define an

element has proved very difficult and one definition after another has been given up as knowledge has grown.

The atomic theory must stand until a better theory is formulated explaining the laws of combination. This theory in its simple form is independent of speculation as to the nature of the atom. Of course the views as to this nature have greatly changed with the growth of knowledge and the chemist has learned to be cautious in his attempts at definition. It is enough for him to know that the supposedly unchanging atom is at least unchanged by the forces and the conditions with which he works and that he can safely count upon it to act in the future as it has in the past. It cannot be decomposed so far as is known by any means at his command and even if such decomposition were effected the laws of combination would remain the same.

It may not be simple or a unit in itself. In fact, both chemist and physicist have long known multiplied reasons for believing in its complexity, but under the influences of forces that bring about combination and decomposition it behaves as a simple unit. And so, while the study of this complexity is most fascinating, the discovery of the nature and constitution of the atom can make no change in the part it has played in the upbuilding of chemical science.

But this science is deeply concerned with the constitution of matter. It is the prime object of its striving and we can no longer look upon the atom as the ultimate particle. The numerous light waves of different length revealed in the spectra, the intimate relationship shown in the periodic system, and other facts forbid this. We must go deeper, if possible, and find out how the atom itself is built up.

Prout, in 1814, thought of the atom as built up of hydrogen. Graham in 1863, conceived of one ultimate, common atom in different conditions of movement. In 1887, Crookes suggested a hypothetical primal atom, protyle, which, under the influence of electricity, gave rise to the various elemental atoms. These were, of course, speculations without basis of experiment and serve mainly to show the trend of thought. In fact, being be-

yond the range of experimentation, they were unproductive of useful results.

And so the chemist became cautious in his definition of atoms, regarding them as a series of related bodies, complex in nature and hence probably divisible but indivisible by any means known to him, each remaining as a unit under the influence of the ordinary forces which might be applied to them. Each one made itself known as a group of associated properties, or as Patterson-Muir put it: "The name copper is used to distinguish a certain group of properties that we always find associated together from other groups of associated properties, and if we do not find the group of properties connoted by the term copper, we do not find copper."

The discovery by Sir William Ramsay in 1894 of argon, followed in 1898 by that of neon, krypton, xenon and helium, brought a new phase into the discussion. Here were atoms destitute of all power of combination, even with similar atoms, hence existing as monatomic gases and presenting no so-called chemical properties for comparison. They formed a new group in the periodic system and had to be accounted for in some way.

It is interesting to me personally that as sectional chairman, I delivered an address in 1899 before the section of chemistry of the A. A. A. S. in which I spoke as follows: "Is it not fair to assume that argon, helium and their companion gases, having no affinity, are without electrical charge? Were they without affinity from the beginning or did they start out as ordinary atoms and somehow lose this property and with it the power of entering into union of any kind, even of forming molecules? Can these be the changed atoms of some of our well-known elements, a step nearer to the primal elements and with the electrical charge lost? Perhaps the coming century will unfold the answer."

The answer came much sooner than was expected. In 1903, Rutherford and Soddy from the presence of helium in minerals and its inability to enter into combination, suggested that it was probably the product of radio-active changes. Sir William Ramsay had drawn attention to the fact that helium is only

found in minerals which are radio-active, and in the same year, 1903, Ramsay and Soddy established by direct experiment that there is a continuous production of helium from radium. May I not then reaffirm the belief that these monatomic, uncharged gases are all the products of disintegration changes and that the proof will be forthcoming? In fact, the results obtained already by J. J. Thomson, Ramsay, Winchester, Collie, Patterson and Masson, though disputed, and still in doubt, would seem to prove this for neon and argon in addition to the conclusive evidence for helium.

Let us next see something of the relations of the atom to electricity. Dalton's picture of the atom, as we have seen, was that of an exceedingly small central particle of solid matter surrounded by an atmosphere of heat. Davy, in 1807, supposed that these particles were in different electrical states and so accounted for chemical affinity—a theory which was later variously elaborated by Berzelius and others. Faraday's law, according to Helmholtz, tells us that the same definite quantity of either positive or negative electricity moves always with each univalent atom, or with every unit of affinity of a multivalent atom, and accompanies it in all its motions. This quantity we may call the electric charge of the atoms.

In this same Faraday lecture in 1881, Helmholtz added: "The most startling result of Faraday's law is perhaps this. If we accept the hypothesis that the elementary substances are composed of atoms, we cannot avoid concluding that electricity also, positive as well as negative, is divided into definite elementary portions which behave like atoms of electricity."

From the earliest stages of the atomic hypothesis in the efforts at accounting for affinity and valence, phenomena of combination, the vision of the atom became associated with electricity and more or less material conceptions grew up as to this indispensable and equally indivisible accompaniment.

This brings us then to the atom of Sir J. J. Thomson, which, as first stated, was simply made up of corpuscles of negative electricity or electrons. Of course, there are two steps in the evolution of this idea. First, it must be established that nega-

tive electricity consists of particles or corpuscles. The preponderance of evidence seems to be in favor of this view, though it is still rejected by some of the foremost men in electrical science.

The second step is to connect this with the atom. The electro-chemical theory, Faraday's law, complexity of spectra, etc., lend their support, but the strongest confirmation comes from the production of streams of electrons in the disintegration of radio-active atoms.

The electron, according to the calculations of Thomson, has a diameter of 10^{-5}; that assigned the atom and the mass of the electron would be about one-thousandth that of a hydrogen atom. The original theory of Thomson held that the hydrogen atom with a diameter of 10^{-8} cm. was entirely made up of electrons. In the production of an atom the rotating electrons arrange themselves in a number of concentric shells. The number of electrons in such ring and the number of rings necessary to insure the stability of the atom have been calculated. The radiation of energy by the electrons must be small if the atom is to remain stable. The radiation diminishes rapidly with the number of electrons in the ring and with their velocity. With a velocity one-hundreth that of light, the amount of radiation of a symmetrical group of six electrons is one 10^{-16} that of a single electron moving with the same velocity in the same orbit. And yet this continuous drain must end either in a rearrangement or in an expulsion of electrons from the atom.

At first the whole mass of the atom was supposed to be made up of electrons and the number of these to be large. Later Thomson showed that the number of electrons was about three times the atomic weight. In such case only a minute fraction of the mass could be made up of electrons.

In summing up the account of the hypothesis, it is sufficient to state, as Rutherford does, that the evidence for the existence of electrons and that these are a universal constituent of atoms is strong, but that the atoms are entirely composed of electrons has little positive evidence for and much against it.

In 1904 (Phil. Mag. [6]-7-237), Thomson states his view that the atoms of the elements consist of a number of negatively

electrified corpuscles enclosed in a sphere of uniform positive electrification, such a model atom having been worked out by Lord Kelvin. This recalls Dalton's atom with its enveloping "sphere of heat."

The Rutherford atom is the last stage in the evolution of the modern conception of this one time indivisible, ultimate particle. This has the advantage over the Thomson atom of an experimental as well as a mathematical basis.

Study of radio-activity phenomena lead Rutherford to announce his Disintegration, or Successive Transformation hypothesis. This has been well worked out and is based upon a large number of observations and experiments. As Rutherford says: "The processes occurring in the radio-active elements are of a character quite distinct from any previously observed in chemistry."

"One of the most powerful methods of obtaining information on the internal structure of the atom," writes Rutherford, "lies in the scattering of high speed particles, for example, of α and β particles, in their passage through matter. In consequence of this great energy of motion, a high-speed α or β particle must pass through the atom which lies in its path. The deflection of the charged particle from its rectilinear path as the result of an atomic encounter throws light on the intensity and distribution of the electrical forces within the atom to which these deflections are due. One of the most noticeable features of the scattering of α particles by thin films of matter is that a small fraction of the α particles is deflected through angles of more than 90°. If, for instance, the α particles are allowed to strike upon a thin film of gold, some 8,000 pass through, as may be seen by the scintillations given on a zinc sulphide screen. These suffer a certain amount of deflection or scattering, but one is so much deflected as to return to its source."

There appears to be no doubt that the large deflection sometimes suffered by an α particle is the result of a close encounter with only one atom of matter. The type of atom devised by Kelvin and Thomson, says Rutherford, in which the positive electricity is distributed throughout a sphere of radius com-

parable with the diameter of the atom, does not seem capable, without modification, of producing the large deviations of an α particle which are observed.

"The single large scattering of α particles, however, could be explained by supposing that the atom consisted of a concentrated positive charge at its centre and surrounded by a distribution of electrons to render it electrically neutral. It was necessary to suppose that the greater part of the mass of the atom was associated with the positive charge which for distances up to 3×10^{-12} cm. behaved as if it were concentrated at a point.

"The large angle scattering of the α particles is then almost entirely due to the passage of the α particle through the intense electric field surrounding the central charge. Supposing the electrical force to vary as the inverse square of the distance from the central charge, the positively charged α particle, in passing close to the centre of the atom describes a hyperbolic orbit, the angle of deflection being greater the nearer the α particle passes the centre of the atom."

The laws of scattering to be expected on this hypothesis have been worked out and verified experimentally. The angle of deflection has been found to depend upon the atomic weight and from examination of the metals from gold to aluminum the positive charge of the nucleus was deduced as ½ Ae.

If the α particles are allowed to bombard the light atoms of hydrogen the smaller nucleus of the hydrogen atom will be projected and this has been proved by experiment. The hydrogen nuclei produce scintillations at a range four times as great as that of the α particles. As calculated by G. C. Darwin, the α particle or helium nucleus must have approached the hydrogen nucleus so that their centres were not more than 1.7×10^{-13} cm. distant from one another. The hydrogen atom is taken as composed of one unit charge of negative. electrons and one unit charge of positive electrons.

The Rutherford atom then is made up of a nuclear mass associated with positive electrons (1 unit charge to 2 units mass form a central nucleus which is .0001 of the diameter of the atom). A number of negative electrons in value equal to the

positive nuclear charge circulate around this as an outer shell. The magnitude of the nuclear positive charge in terms of the hydrogen ion charge is probably the same as the atomic number or number of place occupied by the element in the periodic table.

Such an atom as that of Rutherford is, as Soddy observes, not stable according to ordinary electro-dynamical laws since there is nothing to prevent the dispersion of the extremely concentrated central positive charge but, he adds, it is now recognized that these laws require modifications. The model has been used with very considerable success in conjunction with Planck's theory of quanta and leads to results in connection, for example, with the series relationships of the hydrogen and helium spectra in striking accord with experimental determinations.

A LIST OF PLANTS GROWING SPONTANEOUSLY IN HENDERSON COUNTY, N. C.

BY EDWARD READ MEMMINGER

The following list summarizes the results of years of study of the Flora of Henderson County, but being the work of but one collector is necessarily incomplete. I have entered herein only plants which I have myself seen. Specimens of most of the plants listed are in my private collection and many in Columbia University, N. Y., herbarium.

Henderson County is situated in the western Alpine section of the State; most of the county lying west of the Blue Ridge, and includes in its boundary all sorts of topographic conformations, from the level meadow lands of the French Broad River and its tributaries to mountains of 3,000—4,000 feet in altitude. Most of the level lands of the county are at an elevation of 2,000 feet above sea level. From its altitude its flora approaches greatly the flora of more northern latitudes, so much so that Gray's Flora of the Northern U. S. is nearly of as much use in the study of this flora as Chapman's Southern Flora.

Though this list adds but few new species to the Flora of the State as heretofore published by Curtis and Hyams, yet it extends the ranges of many plants beyond the limits set forth in those lists, and so tends to give us a more accurate knowledge of the distribution of the plants of the State.

The question of nomenclature being in such an unsettled state I have generally adhered to that of Britton and Brown's Illustrated Flora of the Northern States and Canada rather than to the new, radical nomenclature of Dr. Small's Southern Flora.

As the Graminae and Cyperaceae have not been duly studied many species that grow in this country are wanting from this list.

I desire herein to acknowledge the assistance kindly given me in the identification of many species by Dr. Small, Mr. W. W. Ashe and Mr. Biddle of the Biltmore Herbarium.

The list follows:

PTERIDOPHYTES

Polypodiaceae

Polypodium vulgare L.
Phegopteris hexagonoptera (Michx.) Fee.
Pteris aquilina L.
Pteris aquilina caudata (L.) Hook.
Adiantum pedatum L.
Woodwardia areolata (L.) Moore.
Camptosorus rhizophyllus (L.) Link.
Asplenium Triochomanes L.
Asplenium Felix-femina (L.) Bernh.
Asplenium platyneuron (L.) Oakes.
Asplenium acrostichoides Sw.
Dryopteris acrostichoides (Michx.) Kuntze.
Dryopteris noveboracensis (L.) A. Gray.
Dryopteris marginalis (L.) A. Gray.
Dicksonia punctilobula (Michx.) A. Gray.
Onoclea sensibilis L.
Lygodium palmatum (Bernh.) Sw.
Osmunda regalis L.
Osmunda cinnamomea L.

Ophioglossaceae

Botrychium ternatum (Thunb.) Sw.
Botrychium virginianum (L.) Sw.

Lycopodiaceae

Lycopodium lucidulum Michx.
Lycopodium obscurum L.
Lycopodium complanatum L.

GYMNOSPERMS

Coniferae

Pinus virginiana Mill.
Pinus echinata Mill.
Pinus rigida Mill.
Pinus strobus L.

Abies Fraseri (Pursh) Lindl.
Tsuga canadensis (L.) Carr.
Tsuga caroliniana Engelm. Found only east of the Blue Ridge.
Juniperus virginiana L.

MONOCOTYLEDONS

Typhaceae

Typha latifolia L.
Sparganium americanum Nutt.

Alismaceae

Sagittaria latifolia pubescens (Muhl.) Smith.
Sagittaria graminea Michx.

Graminae

Syntherisma sanguinalis (L.) Nash.
Panicum capillare L.
Panicum viscidum Ell.
Panicum clandestinum L.
Ixophorus glaucus (L.) Nash.
Homalocenchrus oryzoides (L.) Poll.
Andropogon scoparius Michx.
Andropogon virginicus L.
Andropogon glomeratus (Walt.) B. S. P.
Sorghum nutans Gray.
Anthoxanthum odoratum L.
Agrostis alba L.
Agrostis perennans (Walt.) Tuck.
Stipa avenacea L.
Deschampsia flexuosa (L.) Trin.
Trisetum pennsylvanicum (L.) Beauv.
Holcus lanatus L.
Gymnopogon ambigua (Michx.) B. S. P.
Festuca nutans Willd.
Poa pratensis L.
Eragrostis secundiflora Presl.
Uniola laxa (L.) B. S. P.
Elymus canadensis L.

Cyperaceae

Scirpus cyperinus Eriophorum (Michx.) Britt.
Eriophorum virginicum L.
Carex crinita Lam.
Carex straminea mirabilis Tuck.
Carex vulpinoidea Michx.
Carex lurida Wahl.
Carex folliculata L.
Carex stricta Lam.
Carex laxiflora patuliflora (Dewey) Carey.

Araceae

Arisaema triphyllum (L.) Torr.
Arisaema quinatum (Nutt.) Schott.
Peltandra virginica (L.) Kunth.
Orontium aquaticum L.

Eriocaulaceae

Eriocaulon decangulare L.

Commelinaceae

Tradescantia virginiana L.
Tradescantia montana Shuttlw.
Commelina virginica L.

Pontederiaceae

Pontederia cordata L.

Juncaceae

Juncoidea campestris (L.) Kuntze.
Juncus effusis L.

Liliaceae

Tofieldia glutinosa (Michx.) Pers.
Chamaelirium luteum (L.) A. Gray.
Stenanthium gramineum (Ker.) Morong.
Melanthium virginicum L.
Melanthium latifolium Desr.
Uvularia perfoliata L.
Uvularia sessilifolia L.
Uvularia puberula Michx.

Chrosperma muscaetoxicum (Walt.) Kuntze.
Lilium carolinianum Michx.
Lilium canadense L.
Lilium superbum L.
Aletris farinosa L.
Erythronium americanum Ker.
Trillium erectum L.
Trillium grandiflorum (Michx.) Salisb.
Trillium stylosum Nutt.
Trillium cernuum L.
Medeola virginiana L.
Polygonatum biflorum (Walt.) Ell.
Polygonatum commutatum (R. & S.) Dietr.
Disporum lanuginosum (Michx.) Nichols.
Vagnera racemosa (L.) Morong.
Convallaria majalis L.
Clintonia umbellulata (Michx.) Torr.
Smilax ecirrhata (Engelm.) Wats.
Smilax glauca Walt.

Dioscoreaceae

Dioscorea villosa L.

Amaryllidaceae

Hypoxis hirsuta (L.) Coville.

Iridaceae

Iris versicolor L.
Iris cristata Ait.
Iris verna L.
Sisyrinchium graminoides Bicknell.
Sisyrinchium augustifolium Mill.

Orchidaceae

Achroanthes unifolia (Michx.) Raf.
Leptorchis liliifolia (L.) Kuntze.
Corallorrhiza Corallorrhiza (L.) Kars.
Corallorrhiza odontorhiza (Willd.) Nutt.
Corallorrhiza multiflora Nutt.
Aplectrum spicatum (Walt.) B. S. P.

Tripularia unifolia (Muhl.) B. S. P.
Limodorum tuberosum L.
Pogonia ophioglossoides (L.) Ker.
[1] Pogonia trianthophora (Sw.) B. S. P.
Pogonia divaricata (L.) R. Br.
Arethusa bulbosa L.
Orchis spectabilis L.
Habenaria ciliaris (L.) R. Br.
Habenaria lacera (Michx.) R. Br.
Habenaria cristata (Michx.) R. Br.
Habenaria peramoena Gray.
Habenaria blephariglottis (Willd.) Torr.
Habenaria integra (Nutt.) Spreng.
Habenaria clavellata Spreng.
Gyrostachys cernua (L.) Kuntze.
Gyrostachys gracilis (Bigel.) Kuntze.
Gyrostachys odorata (Nutt.) Kuntze.
Peramium pubescens (Willd.) Mac M.
Cypripedium acaule Ait.
Cypripedium hirsutum Mill.
Cypripedium parviflorum Salisb.

DICOTYLEDONS

Salicaceae

Salix nigra Marsh.
Salix tristis Ait.

Juglandaceae

Hicoria alba (L.) Britton
Hicoria glabra (Mill.) Britton.
Hicoria ovata (Mill.) Britton
Juglans nigra L.
Juglans cinerea L.

[1] The illustration of this plant in Britton & Brown's Illustrated Flora, 1st edition does not well represent our plant. The lip of our plant is decidedly three lobed with the lateral lobes connivent above the central lobe, which latter is longer than the others.

Moreover it is certainly crested with a green crest, beginning as two green ridges which coalesce toward the end of the lip. The crest consists of separate, elevated ridges which would seem to come under the definition of "crested" as given in Gray's Glossary.

Betulaceae

Carpinus caroliniana Walt.
Corylus americana Walt.
Corylus rostrata Ait.
Betula nigra L.
Betula lenta L.
Betula lutea Michx. f.
Alnus rugosa (Du Roi.) K. Koch.

Fagaceae.

Fagus americana Sweet.
Quercus rubra L.
Quercus coccinea Wang.
Quercus velutina Lam.
Quercus digitata (Marsh.) Sudw.
Quercus marylandica Michx.
Quercus imbricaria Michx.
Quercus alba L.
Quercus minor (Marsh.) Sarg.
Quercus Prinus L.
Castanea dentata (Marsh.) Borkh.
Castanea pumila (L.) Mill.

Urticaceae

Urticastrum divaricatum (L.) Kuntze.
Boehmeria cylindrica (L.) Willd.

Santalaceae

Pyrularia pubera Michx.
Comandra umbellata (L.) Nutt.

Loranthaceae

Phoradendron flavescens (Pursh.) Nutt.

Aristolochiaceae

Asarum Memmingeri Ashe.

Polygonaceae

Rumex acetosella L.
Rumex crispus L.
Polygonum Persicaria L.

Polygonum orientale L.
Polygonum tenue Michx.
Polygonum ramosissimum Michx.
Polygonum sagittatum L.
Polygonum dumetorum L.
Polygonum virginiana L.

Chenopodiaceae

Chenopodium album L.

Amaranthaceae

Amaranthus hybridus L.

Phytolaccaceae

Phytolacca decandra L.

Caryophyllaceae

Silene virginica L.
Silene stellata Ait.
Saponaria officinalis L.
Arenaria glabra Michx.
Alsine pubera (Michx.) Britton.
Alsine media L.
Cerastium vulgatum L.
Anychia dichotoma Michx.
Anychia canadensis L.

Portulacaceae

Talinum teretifolium Pursh.

Nymphaeaceae

Nymphaea advena Soland.

Ranunculaceae

Clematis virginiana L.
Anemone quinquefolia L.
Anemone trifolia L.
Anemone virginiana L.
Syndesmon thalictroides (L.) Hoffing.
Thalictrum dioicum L.
Thalictrum clavatum DC.
Thalictrum polygamum Muhl.

Thalictrum macrostylum (Shultt.) Small and Heller. Rare, growing in dry woods.
Thalictrum purpurascens L.
Thalictrum revolutum DC.
Trautvetteria carolinensis (Walt.) Vail.
Ranunculus abortivus L.
Ranunculus recurvatus Poir.
Ranunculus septentrionalis Poir.
Ranunculus hispidus Michx.
Aquilegia canadensis L.
Aconitum uncinatum L.
Aconitum uncinatum var. alpinum. This variety grows on Sugar Loaf Mountain and is perfectly erect, ½ to 2 feet high, with leaves smaller and more deeply and more shapely divided than the common form. In this it approaches *Aconitum noveboracense* Gray.
Xanthorrhiza apiifolia L'Her.
Cimicifuga racemosa (L.) Nutt.

Magnoliaceae

Magnolia Fraseri Walt.
Liriodendron Tulipifera L.

Calycanthaceae

Butneria florida (L.) Kearney.
Butneria fertilis (Walt.) Kearney.

Berberidaceae

Caulophyllum thalictroides Michx. In mountain coves.
Podophyllum peltatum L.

Lauraceae

Sassafras Sassafras (L.) Karst.
Benzoin Benzoin (L.) Coulter.

Papaveraceae

Capnoides sempervirens (L.) Borck.
Sanguinaria canadensis L.

Cruciferae

Arabis canadensis L.
Sisymbrium thalianum (L.) J. Gay.
Bursa Bursa-pastoris (L.) Britton.
Cardamine hirsuta L.
Draba verna L.

Sarraceniaceae

Sarracenia purpurea L.
Sarracenia rubra Walt. This plant has a delightful odor of violets not mentioned in books.

Droseraceae

Drosera rotundifolia L.

Saxifragaceae

Heuchera americana L.
Heuchera hispida Pursh.
Heuchera villosa Michx.
Heuchera pubescens Pursh.
Saxifraga Michauxii Britton.
Hydrangea radiata Walt.

Hamamelidaceae

Hamamelis virginica L.
Itea virginica L.

Platanaceae

Platanus occidentalis L.

Rosaceae

Opulaster opulifolius (L.) Kuntze.
Spiraea salicifolia L.
Spiraea tomentosa L.
Aruncus Aruncus (L.) Karst.
Porteranthus trifoliatus (L.) Britt.
Porteranthus stipulatus (Muhl.) Britt.
Agrimonia striata Michx.
Agrimonia pumila Muhl.
Agrimonia parviflora Soland.
Sanguisorba canadensis L.
Geum virginianum L.

Geum flavum (Porter) Bicknell.
Potentilla monspeliensis L.
Potentilla canadensis L.
Potentilla canadensis var. simplex (Michx.) T.&G.
Fragaria virginiana Duchesne.
Rubus hispidus L.
Rubus trivialis Michx.
Rubus occidentalis L.
Rubus villosus Ait.
Rosa carolina L.
Rosa rubiginosa L.
Rosa pumilis Marsh.
Crataegus uniflora Muench.
Crataegus flava Ait.
Crataegus cordata (Mill.) Ait.
Crataegus Crus-galli L.
Amelanchier canadensis (L.) Medic.
Amelanchier Botryapium (L.) DC.
Malus augustifolia (Ait.) Michx.
Malus coronaria (L.) Nutt.
Aronia arbutifolia (L.) Ell.
Aronia nigra (Walld.) Britt.
Prunus cuneata Raf.
Prunus umbellata Ell.
Prunus serotina Ehrh.

Leguminosae

Morongia uncinata (Walld.) Britton.
Cassia nictitans L.
Cassia chamaecrista L.
Cassia marylandica L.
Trifolium agrarium L.
Trifolium pratense L.
Trifolium repens L.
Trifolium procumbens L.
Amorpha fruticosa L.
Amorpha virgata Small.

Robinia pseudacacia L.
Robinia hispida L.
Robinia Boyntonii Ashe.
Robinia nana (Ell.) Sharp.
Cracca virginana L.
Phaseolus polystachyus (L.) B. S. P.
Vicia sativa L.
Vicia caroliniana Walt.
Stylosanthes biflora (L.) B. S. P.
Lespedeza repens (L.) Bart.
Lespedeza procumbens Michx.
Lespedeza Nuttalii Darl.
Lespedeza Stuvei Nutt.
Lespedeza hirta (L.) Ell.
Lespedeza virginica (L.) Britton.
Lespedeza capitata Michx.
Lespedeza striata (Thunb.) H. & A.
Apios Apios (L.) Mac M.
Clitoria mariana L.
Falcata comosa (L.) Kuntze.
Falcata Pitcheri (F. & G.) Kuntze.
Baptisia tinctoria (L.) R. Brown.
Thermopsis caroliniana (Nutt.) M. A. C.
Thermopsis fraxinifolia M. A. C.
Thermopsis mollis (Michx.) M. A. C.
Meibomia nudiflorum (L.) Kuntze.
Meibomia paniculata (L.) Kuntze.
Meibomia paniculata Chapmani Britton.
Meibomia bracteosa (Michx.) Kuntze.
Meibomia Michauxii Vail.
Meibomia laevigata (Nutt.) Kuntze.
Meibomia grandiflora (Walt.) Kuntze.
Meibomia stricta (Pursh) Kuntze.
Meibomia arenicola Vail.
Meibomia obtusa (Muhl.) Vail.
Meibomia Dillenii (Darl.) Kuntze.
Meibomia canescens (L.) Kuntze.

Meibomia rigida (Ell.) Kuntze.
Meibomia rhombifolia (Ell.) Vail.
Galactia volubilis (L.) Britton.

Linaceae

Linum medium (Planc) Britton.
Linum striatum Walt.
Linum virginianum L.

Oxalidaceae

Oxalis stricta L.
Oxalis cymosa Small.

Geraniaceae

Geranium maculatum L.
Geranium carolinianum Muhl.

Polygalaceae

Polygala cruciata L.
Polygala Curtisii forma albiflora.
Polygala senega L.
Polygala ambigua Nutt.
Polygala mariana Mill.
Polygala viridescens L.

Euphorbiaceae

Euphorbia maculata L.
Euphorbia corollata L.
Acalypha virginica L.
Acalypha gracilens A. Gray.
Crotonopsis linearis Michx.

Anacardiaceae

Rhus glabra L.
Rhus copalina L.
Rhus radicans L.
Rhus Toxicodendron L.
Rhus vernix L.

Aquifoliaceae

Ilex opaca Ait.
Ilex ambigua Chapm.
Ilex verticillata (L.) Gray.

Sapindaceae

Acer saccharinum L.
Acer carolinianum Walt.
Acer rubrum L.

Balsaminaceae

Impatiens biflora Walt.
Impatiens aurea Muhl.

Rhamnaceae

Ceanothus americanus L.

Celastraceae

Euonymus americanus L.
Euonymus obovatus Nutt.

Vitaceae

Vitis Labrusca L.
Vitis aestivalis Michx.
Ampelopsis quinquefolia Michx.

Tiliaceae

Tilia heterophylla Vent.

Malvaceae

Abutilon Abutilon L.

Hypericaceae

Hypercium maculatum Walt.
Hypericum canadense L.
Hypericum virgatum. Lam.
Sarothra gentianoides L.
Ascyrum stans Michx.
Ascyrum hypericoides L.

Cistaceae

Helianthemum canadense (L.) Michx.
Lechea racemulosa Michx.

Violaceae

Viola palmata L.
Viola villosa Walt.
Viola ovata Nutt.
Viola obliqua Hill.

Viola pedata L.
Viola rotundifolia Michx.
Viola blanda Willd.
Viola primulaefolia L.
Viola hastata Michx.
Viola pubescenes Ait.
Viola scabriuscula (T. & G.) Schwein.
Viola canadensis L.
Viola rostrata Pursh. Only found East of the Blue Ridge.
Viola tripartita Ell.

Passifloraceae

Passiflora incarnata L.

Lythraceae

Parsonsia petiolata (L.) Rusby.

Melastomaceae

Rhexia mariana L.
Rhexia virginica L.

Onagraceae

Ludvigia alternifolia L.
Ludvigia hirtella Raf.
Epilobium coloratum Muhl.
Kneiffia fruticosa (L.) Raimann.
Kneiffia fruticosa pilosella (Raf.) Britton.
Kneiffia glauca (Michx.) Spach.
Oenothera laciniata Hill.
Onagra biennis (L.) Scop.

Araliaceae

Aralia spinosa L.

Umbellifereae

Sanicula gregaria Bick.
Sanicula canadensis L.
Eryngium aquaticum L.
Eryngium intergrifolium Walt.
Cicuta maculata L.
Zizia aurea (L.) Koch.

Zizia Bebbii (Coult. & Rose) Britton.
Zizia cordata (Walt.) DC.
Ligusticum canadense (L.) Britton.
Oxypolis rigidus (L.) Britton.
Angelica villosa (Walt.) B. S. P.

Cornaceae

Cornus florida L.
Cornus amomum Mill.
Nyssa sylvatica Marsh.

Ericaceae

Clethra acuminata Michx.
Chimaphila maculata (L.) Pursh.
Monotropa uniflora L.
Hypopitys Hypopitys (L.) Small.
Monotropsis odorata Ell.
[2] Epigaea repens L.
Gaultheria procumbens L.
Leucothoe Catesbaei (Walt.) A. Gray.
Leucothoe racemosa (L.) A. Gray.
Leucothoe recurva (Buckl.) A. Gray.
Chamaedaphne calyculata (L.) Moench.
Xolisma ligustrina (L.) Britton.
Oxydendrum arboreum (L.) DC.
Kalmia latifolia L.
Kalmia augustifolia L.
Rhodondron maximum L.
Rhodondron catawbiense Michx.
Rhodondron punctatum Andr.
Azalea nudiflora L.
Azalea lutea L.
Azalea arborescens Pursh.
Azalea viscosa L.
Azalea viscosa nitida (Pursh.) Britton.

[2] A form of this plant grows on Wolf mountain near Lake Kanuga which differs from the usual form in having larger and more hairy leaves, being robust and ascending, not lying so flat on the ground and having the flowers slightly different in outline and not clustered, but distributed in a longer inflorescense. It was submitted to Dr. Small, but he regarded it only as a form, and much like specimens he had from South Carolina.

Gaylussacia resinosa (Ait.) T. & G.
Gaylussacia dumosa (Andr.) T. & G.
Vaccinium corymbosum L.
Vaccinium vacillans Kalm.
Vaccinium pallidum Ait.
Vaccinium stamineum L.

Diapensiaceae

Galax aphylla L.

Primulaceae

Lysimachia quadrifolia L.
Lysimachia terrestris (L.) B. S. P.
Steironema lanceolatum (Walt.) A. Gray.
Steironema ciliatum (L.) Raf.

Ebenaceae

Diospyros virginiana L.

Styracaceae

Mohrodendron carolinum (L.) Britton.

Oleaceae

Fraxinus americanna L.
Chionanthus virginica L.

Gentianaceae

Sabbatia angularis (L.) Pursh.
Sabbatia campanulata (L.) Torr.
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Gentiana villosa L.
Gentiana quinquefolia L.
Bartonia virginica (L.) B. S. P.
Obolaria virginica L.

Apocynaceae

Apocynum androsaemifolium L.

Asclepiadaceae

Asclepias quadrifolia Jacq.
Asclepias obtusifolia Michx.
Asclepias tuberosa L.
Asclepias incarnata L.

Asclepias variegata L.
Asclepias exaltata (L.) Muhl.

Convolvulaceae

Quamoclit Quamoclit (L.) Britton.
Ipomoea pandurata (L.) Meyer.
Convolvulus Spithamacus L.
Cuscuta Gronovii Willd.
Cuscuta compacta Juss.

Polemoniaceae

Phlox paniculata L.
Phlox glaberrima L.
Phlox amoena Sims.
Phlox divaricata L.

Verbenaceae

Verbena urticifolia L.

Labiatae

Lycopus virginicus L.
Lycopus sessilifolius A. Gray.
Cunila origanoides (L.) Britt.
Koellia flexuosa (Walt.) Mac M.
Koellia incana (L.) Kuntze.
Koellia montana (Michx.) Kuntze.
Koellia pycnanthemoides (Lavenw) Kuntze.
Koellia clinopodioides (T. & G.) Kuntze.
Collinsonia canadensis L.
Hedeoma pulegioides (L.) Pers.
Glecoma hederacea L.
Salvia lyrata L.
Monarda didyma L.
Monarda punctata L.
Monarda fistulosa L.
Monarda Clinopodia L.
Prunella vulgaris L.
Scutellaria lateriflora L.
Scutellaria incana Muhl.
Scutellaria pilosa Michx.

Scutellaria integrifolia L.
Scutellaria cordifolia Muhl.
Physostegia virginiana (L.) Benth.
Lamium amplexicaule L.
Stachys aspera Michx.
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Trichostema lineare Nutt.

Solonaceae

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Solanum carolinense L.
Datura stramonium L.

Serophulariaceae

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Chelone glabra L.
Chelone Lyoni Pursh.
Chelone Cuthbertii Small.
Penstemon hirsutus (L.) Wlld.
Penstemon Penstemon (L.) Wlld.
Linaria Linaria (L.) Karst.
Mimulus ringens L.
Gratiola viscosa Schwein.
Veronica officinalis L.
Veronica serpyllifolia L.
Dasystoma Pedicularia (L.) Benth.
Dasystoma flava (L.) Wood.
Dasystoma virginica (L.) Britton.
Gerardia tenuifolia Vahl.
Gerardia Skinneriana Wood.
Gerardia purpurea L.
Pedicularis canadensis L.
Melampyrum lineare Lam.

Lentibulariaceae

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Orbobanchaceae

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Lobelia leptostachys A. D. C.
Lobelia inflata L.

Lobelia glandulifera (A. Gray) Small.
Lobelia cardinalis L.
Lobelia amoena Michx.
Lobelia syphilitica L.
Lobelia spicata Lam.

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Lacinaria spicata (L.) Kuntze.
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Eupatorium ageratoides L. f.
Eupatorium perfoliatum L.
Eupatorium sessilifolium L.
Eupatorium album L.
Eupatorium purpureum L.
Eupatorium trifolium L.
Eupatorium serotinum Michx.
Eupatorium semiserratum DC.
Eupatorium incarnatum Walt.
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Aster Curtisi T. & G.
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Aster puniceus L.
Aster tenuifolius L.
Aster lateriflorus (L.) Britton.
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Aster Tradescanti L.
Aster acuminatus Michx.
Aster divaricatus L.
Aster junceus Ait.
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Doellingeria infirma (Michx.) Greene.

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Solidago hispida Muhl.
Solidago Boottii Hook.
Solidago erecta Pursh.
Solidago odora Ait.
Solidago serotina Ait.
Solidago rugosa Mill.
Solidago monticola T. & G.
Solidago lancifolia T. & G.
Solidago Buckleyi T. & G.
Solidago canadensis L.
Solidago puberula Nutt.
Solidago nemoralis Ait.
Solidago Curtisii T. & G.
Brachychaeta sphacelata (Raf.) Britt. Sugarloaf Mountain.
Chrysopsis mariana L.
Chrysopsis graminofolia (Michx.) Nutt.
Antennaria plantaginifolia (L.) Richards.
Gnaphalium obtusifolium L.
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Parthenium integrifolium L.
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Rudbeckia laciniata L.
Rudbeckia hirta L.
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Verbesina occidentalis (L.) Walt.

Coreopsis major Walt.
Coreopsis pubescens Ell.
Coreopsis crassifolia Ait.
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Bidens trichosperma var. tenuiloba (A. Gray) Britton.

Bidens bipinnata L.
Bidens bipinnata var. minor. Very delicate, small 10 cm. high, in dense shade on rocks.

Bidens frondosa L.
Bidens connata Muhl.
Galinsoga parviflora Cav. Introduced, a nuisance in gardens.

Helenium autumnale L.
Achillea millefolium L.
Anthemis cotula L.
Chrysanthemum Leucanthemum L.
Senecio aureus L.
Senecio Smallii Britton.
Senecio Balsamitae Muhl.
Senecio millefolium T. & G.
Senecio Memmingeri Britton.
Erechtites hieracifolia (L.) Raf.
Mesadenia atriplicifolia (L.) Raf.
Synosma suaveolens (L.) Raf.
Carduus muticus (Michx.) Pers.
Carduus altissimus L.
Adopogon carolinianum (Walt.) Britton.
Hieracium paniculatum L.
Hieracium venosum L.
Hieracium Gronovii L.
Hieracium scabrum Michx.
Nabalus altissimus (L.) Hook.
Nabalus serpentarius (Pursh) Hook.
Nabalus albus (L.) Hook.

Nabalus integrifolius Cap.
Nabalus trifoliolatus Cap.
Lactuca canadensis L.
Sonchus oleraceus L.
Sonchus asper (L.) All.

THE STABILITY OF RESIN ACIDS AT SLIGHTLY ELEVATED TEMPERATURES—A CORRECTION *

BY CHAS. H. HERTY AND H. L. COX

Schwalbe,[1] noting the evolution of carbon dioxide when rosin was heated to 140° C. in air freed from carbon dioxide, interpreted this result as the breaking down of the carboxyl groups of the acids contained in the rosin.

Herty and Dickson [2] showed that the carbon dioxide obtained by Schwalbe was due to one or more of the following factors: traces of spirits of turpentine in the rosin, moisture, oxygen of the air conducted through the heating flask and oxygen absorbed by the rosin previous to the experiment. Rosin, prepared from fresh oleoresin, freed completely from spirits of turpentine during distillation, and heated in a current of dry nitrogen, showed no signs of decomposition at 140°, even after seven hours' heating at this temperature.

But they further stated that if the resin acids were prepared cold and freed from the other constituents of the fresh oleoresin, such acids heated in dry nitrogen melted at 65°-70° C. and immediately evolved carbon dioxide in quantity. No explanation was offered of this seeming paradox, the results, however, indicating a probable decomposition of some of the acid constituents of the oleoresin during its separation by distillation, in the woods, into rosin and spirits of turpentine.

Later, in seeking an explanation, two possibilities suggested themselves: *First,* that during the preparation of the acids some oxygen might have been absorbed from the air, in spite of the precautions taken; *second,* that the drying of the acids in a desiccator over phosphorus pentoxide may have been imperfect. This last idea was suggested during the course of another investigation in this laboratory, in which great difficulty was experienced in drying perfectly resin acids precipitated

* Reprinted from the Journal of Industrial and Engineering Chemisty, Volume 6, No. 9, page 782. September, 1914.
Presented at the 49th Meeting of the American Chemical Society, Cincinnati, April 6-10, 1914.

[1] *Zeit. angew, Chem.,* 18, 1825.

[2] THIS JOURNAL, 1, 68.

from water solutions of their potassium salts by acidifying with hydrochloric acid.

To test these ideas, a perfectly fresh specimen of the oleoresin of *Pinus Heterophylla* (Cuban or slash pine) was obtained from Florida. Five grams of this specimen were dissolved in 50 cc. of ether, the solution filtered and the potassium salts of the acids immediately precipitated by slowly adding 10 cc. of a very concentrated water solution of potassium hydroxide, approximately 15 normal, a salting-out process. This precipitate, freed as far as possible from the potassium hydroxide solution by draining, was thoroughly mixed with glass wool to make the mass more permeable to the extractive, and extracted with ether one hundred hours in a Soxhlet extractor until no further traces of spirits of turpentine or resene could be detected in the fresh extract. The extracted mass was treated with cold water and the solution of the potassium salts filtered from the glass wool. The free acids were precipitated by slow addition of dilute hydrochloric acid, just to acidity, filtered upon a Buchner funnel, washed with water until free from chlorides, and rapidly dried as far as possible with the suction pump. The partly dried acids were dissolved in ether and the removal of water completed by addition of freshly ignited sodium sulfate. This solution was rapidly filtered into the heating flask in which the experiment was to be conducted.

This flask had been previously filled with nitrogen obtained by drawing air successively through a water solution of ammonia; over heated copper; through dilute sulfuric acid; two wash bottles containing alkaline pyrogallic acid solution; concentrated sulfuric acid and two drying tubes—one containing calcium chloride and soda lime, the other phosphorus pentoxide mixed with pumice. The heating flask, surrounded by a bath of cottonseed oil in a beaker, contained a thermometer, and its outlet tube, during the heating experiment, dipped below the surface of freshly filtered barium hydroxide solution in the precipitating flask. A tube of soda-lime was placed between the precipitating flask and the aspirator.

The ether solution of the resin acids was evaporated to

dryness in the heating flask in a current of dry nitrogen under reduced pressure, barium hydroxide solution was then filtered into the precipitating flask and the temperature of the heating flask slowly raised, nitrogen being drawn through the flask throughout the experiment.

The acids melted at about 73°C., but no gas evolution could be detected in the melted mass, even while the temperature was being raised to 140° C. and so maintained for an hour, nor was there the slightest precipitation of barium carbonate in the precipitating flask. It is evident, therefore, that these resin acids, if protected from oxygen and thoroughly freed from water, are perfectly stable at 140° C.

CHAPEL HILL, N. C.

ISOPRENE FROM COMMERCIAL TURPENTINES *

BY CHAS. H. HERTY AND J. O. GRAHAM

In connection with the studies of rubber made by polymerization of isoprene, Harries and Gottlob [1] described a method for the preparation of isoprene from spirits of turpentine by means of the "isoprene lamp." In this method the spirits of turpentine is boiled in a flask, in which, just below the neck, is suspended an electrically heated platinum wire coiled somewhat like the filament of a tantalum incandescent bulb. A part of the vapors are decomposed as they pass upward across the heated wire. The flask is attached to an upright condenser maintained at a temperature of 50° C., for condensing the unchanged vapors of spirits of turpentine. The upright condenser is connected with an inclined condenser fed with tap water and this in turn is connected with a receiver surrounded by a freezing mixture. The crude product collected in this receiver is fractionated and the isoprene collected as the fraction boiling between 35° and 37° C.

With this apparatus, Harries and Gottlob obtained a yield of only 1 per cent of isoprene from commercial pinene as against 30 to 50 per cent from commercial limonene. They, therefore, concluded that the yield of isoprene from spirits of turpentine is due chiefly to the presence of dipentene (limonene).

In view of the general interest in the production of rubber from isoprene, it seemed desirable to extend these studies to commercial products closely related to spirits of turpentine and to test further the point mentioned above as to the origin of the isoprene from spirits of turpentine, accordingly, studies have been made using commercial spirits of turpentine, fractions of the same, pine oil, the volatile oil of *Pinus serotina* (pond pine) and refined spruce pine teurpentine.

The apparatus used closely resembled that of Harries and Gottlob, short-circuiting of the sections of red hot platinum wire being prevented by winding the wire on a pipe stem triangular

* Reprinted from the Journal of Industrial and Engineering Chemistry, Volume 6, No. 10, page 803. October, 1914.
Presented at the 48th Meeting of the American Chemical Society, Rochester, September 8-12, 1913.

[1] *Ann.*, **383**, 228.

prism. A constant current of 2.25 amperes maintained an even temperature of the wires at a red glow. The flask containing the turpentine was heated by means of a bath of cottonseed oil containing a thermometer. The receiving vessel in the freezing mixture, salt and ice, was a small sulfurous acid condenser. The crude products were refined by distillation through a Hempel column filled with glass beads. The yield of pure isoprene in each of the experiments which follow represents the fraction collected between 35° and 37° C.

SPIRITS OF TURPENTINE

200 cc. of spirits of turpentine were boiled in the isoprene lamp until condensation ceased in the inclined condenser. At two-hour intervals the crude product was removed from the receiver and fractionated. Following this experiment, similar experiments were conducted with 200 cc. fractions of spirits of turpentine obtained by fractionation by means of a Young's still head. The first fraction was collected between 155° and 156° C., the pinene fraction; the second, between 169° and 175° C.; the third fraction from 175° C. up. These two last fractions should include the dipentene content of the original spirits of turpentine.

The heating of the two last fractions was continued only two hours, as after that time no further condensation could be observed in the inclined condenser.

The results of the three experiments are shown in Table I:

TABLE I

Substance used	Time of heating Hrs.	Temperature of oil bath	Volume of distillate Crude Cc.	Volume of distillate Refined Cc.	Per cent of isoprene	Volume of residue in heat'g flask Cc.
	2	175°	17	6.5	3.25	...
Spirits of turpentine...........	2	175°	12	3.5	1.75	...
	2	185°	8	1.0	0.50	103
Totals....................	6	....	37	11.0	5.50	103
Fraction 155°—156°............						
	2	175°	10	6	3.00	...
	2	175°	7	5	2.50	...
	2	175°	6	4	2.00	...
	2	175°	4	1	0.50	...
Totals....................	8	....	27	16	8.00	50
Fraction 169°—175°	2	180°	6.5	1	0.50	192
Fraction 175°+	2	185°	3.25	0	0.00	195

From the direct proof thus obtained it is evident that the yield of isoprene from spirits of turpentine is due to pinene, rather than to dipentene as claimed by Harries and Gottlob.

THE VOLATILE OIL OF PINUS SEROTINA

This substance has been studied by Herty and Dickson [2] and was found to be particularly rich in limonene. Since Harries and Gottlob obtained 30 to 50 per cent of isoprene from commercial limonene with the isoprene lamp, it seemed desirable to study this volatile oil and compare its yield with that from ordinary spirits of turpentine.

In preparing the material from the oleoresin the difficulties formerly met with in distillation by a current of superheated steam were easily overcome by heating the oleoresin at a pressure of one millimeter, the volatile oil readily passing off without any tendency to froth in the flask and with largely decreased opportunity for polymerization during distillation. Table II gives the results with the isoprene lamp.

TABLE II

Substance used	Time of heating Hrs.	Temperature of oil bath	Volume of distillate: Crude Cc.	Volume of distillate: Refined Cc.	Per cent of isoprene	Volume of residue in heat'g flask Cc.
200 cc. of volatile oil of *Pinus serotina*	2.0	175°	6.50	5.0	2.5	...
	2.0	175°	4.75	3.0	1.5	...
	2.5	185°	11.00	8.0	4.0	...
	2.5	185°	11.00	8.0	4.0	25.0
Totals	9.0	....	33.25	24.0	12.0	25.0

No further condensate could be obtained by continued heating of the residue. As was to be expected the yield of isoprene from this volatile oil, rich in limonene, shows a largely increased yield, practically doubled, as compared with ordinary spirits of turpentine.

[2] *J. Am. Chem. Soc.*, **30**, 872.

PINE OIL

When resinous pine wood is finely divided and treated with steam a crude oil distils off which on fractionation yields wood spirits of turpentine and pine oil. Teeple [3] has found that pine oil consists chiefly of α-terpineol. The specimen used in this work showed at 15° C. a specific gravity of 0.9403 and an index of refraction of 1.4901. The results with the isoprene lamp are given in Table III.

TABLE III

Substance used	Time of heating Hrs.	Temperature of oil bath	Volume of distillate: Crude Cc.	Volume of distillate: Refined Cc.	Per cent of isoprene	Volume of residue Cc.
	2	210°	15	4	2.0	...
200 cc. of pine oil	2	210°	10	3	1.5	...
	2	210°	7	1	0.5	125
Totals	6	....	32	8	4.0	125

REFINED SPRUCE PINE TURPENTINE

This substance, consisting chiefly of cymene, is collected as a by-product in blowing off the digesters in the manufacture of wood pulp from spruce pine. The specimen was furnished by the A. D. Little Laboratory of Boston. It showed at 15° C. a specific gravity of 0.8639 and an index of refraction of 1.4916; 80 per cent distilled between 171.3° and 174.9°C. 200 cc. of this substance were boiled three hours in the isoprene lamp but no crude distillate could be observed.

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[3] *J. Am. Chem. Soc.*, **30**, 413.

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JOURNAL

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ELISHA MITCHELL, D. D.

BY EX-PRESIDENT KEMP P. BATTLE, LL. D.,
The last survivor of the Faculty of June, 1857

Elisha Mitchell was born in Washington, Litchfield County, Connecticut, August 19th, 1793. His father was a respected farmer, content to live a farmer's life. His mother, Phoebe Eliot, was a descendant of Rev. John Eliot, the "Apostle to the Indians," a learned man, who translated the Bible into the language of the Indians of Massachusetts. Her grandfather was also eminent as a divine and a scientist,—Rev. Jared Eliot, M. D., and D. D. who was honored by the Royal Society of London with a gold medal for a discovery in the manufacture of iron.

Young Mitchell showed from boyhood the talents of the Eliot family. He graduated in Yale University, then College, with high honor in 1813, along with President Longstreet, the author of Georgia Scenes, Dr. Denison Olmstead, author and professor at the University of North Carolina and Yale, and Thomas P. Devereux, Reporter of the Supreme Court of North Carolina. Senator George E. Badger was a classmate but left before graduation.

After graduation he taught in a school for boys at Jamaica, Long Island. In the spring of 1815 he took charge of a school for girls in New London, where he married Maria S.—the Daughter of Dr. Erasmus North, a physician of the City. In the next year on the recommendation of the Chaplain of the Senate, Rev. Sereno E. Dwight, through an active Trustee of this institution, Wm. Gaston, a representative in Congress, he was elect-

ed Professor of Mathematics and Natural Philosophy in this University in place of Dr. Caldwell, made President a second time after the resignation of Dr. Robert H. Chapman. Professor Mitchell reported for duty January 31st, 1818.

He applied himself to his duties with great diligence. To him is the honor of introducing into the curriculum the study of Differential and Integral Calculus, then called Fluxions. His favorite study however was Nature, and in 1825, on the departure of Professor Olmstead to Yale, he was at his own request transferred to the Chair of Chemistry, Geology and Mineralogy, Mr. James Phillips taking his former chair. Botany was also under his charge.

It was at this time that the General Assembly made a small appropriation for a Geologic Survey of the State. For about six months Olmstead was director and then Mitchell succeeded. Each published a short preliminary Report. The appropriation was not renewed.

In 1835 Professor Mitchell made tours through the counties of Johnston, Wayne, Onslow, Craven and Beaufort, and then through Alamance, Guilford, and the counties west, as far as Buncombe, for the study of the Geology, Mineralogy and Botany of the State. He embodied is observations in closely written letters to his wife. These were shortly before her death given to the University by his unmarried daughter Margaret, and were published as one of the James Sprunt Historical Monographs, with annotations by Dr. Battle, the Professor of History. He made subsequent tours in our mountain counties in 1838, 1844 and 1856, discovering in 1844 the highest peak east of the Rocky Mountains, now called in his honor Mount Mitchell.

After the death of President Caldwell in January of this year he was Chairman of the Faculty for a year, until the arrival of President Swain in January 1836, and was an efficient executive officer.

While Dr. Mitchell lived in Connecticut he was a member of the Congregational Church. After his removal to Chapel Hill he joined that of the Presbyterian and was ordained to the

Christian Ministry in 1821. For many years he preached in the University Chapel every alternate Sunday, and often at night in the Union, or Village, Chapel, which in 1848 gave place to the Presbyterian Church edifice.

As a preacher I cannot say that he was eloquent, or inspiring. His manner of delivery was tame and awkward. His eyes were fixed on his manuscript and he never raised his voice, but his sermons were always sound and sensible. He did not follow the old school in claiming that every word of the Holy Scriptures was inspired by God, but thought that mistakes in merely historical matters had occurred by errors of copyists or otherwise.

I recall only one sentence of his sermons. The subject was "Moral Courage" and was ably handled. He began "The man who is on a sidewalk and sees an angry bull approaching with horns lowered ready to gore him, and does not jump over the fence, he is not a brave man, he is a fool." Then he showed the nature of true courage.

For years he was Bursar of the University, in charge of the collecting of tuition fees and other sums and attending to the repair of College Buildings and similar work. The substantial stone walls around the campus were built under his direction. He was also a Justice of the Peace and acting Mayor, building and repairing streets, roads and culverts.

As he grew older, he studied in a room in the South Building to a late hour, and was much relied on in the suppression of disorders. Although he was vigilant in the performance of this duty, the Professors and Tutors in his day being expected to act as police-officers, he always was on the side of leniency in punishment.

As a teacher, in the studies under his charge, and in the Old Testament taught to the Junior classes Sunday afternoons, he was inspiring and interesting. He did not confine his attention to the text-books but often gave facts and incidents gathered from his reading and experience. He did not require laboratory work of his classes, but often performed experiments himself in presence of the class. He indulged occasionally in

humorous anecdotes, which the College critics alleged were handed down from class to class. For instruction in the Geology of North Carolina he published a thin Octavo with that title embodying his researches. He prepared a treatise on Chemistry. He printed a few pages in pamphlet on Botany, and "Statistics, Facts and Dates."

If Dr. Mitchell had used his great brain and uncommonly sound health and strength of body in the study and development of one branch of science he would have been world-famous. But his eager curiosity urged him to more or less partial dipping into many subjects. He read voluminous theological works. He devoured Blackstone and other legal literature in order to qualify himself for the office of Justice of the Peace. He learned the use of theodolites and other instruments, and was a skillful engineer. He was theoretically versed in Astronomy, and Political Economy, Agriculture, Horticulture, Mining.

He was learned in Higher Mathematics. He was a vast reader of the history, poetry, political problems, philosophy, in truth of the several literatures of ancient and modern times. The learned and unlearned of the University and of the village called him with undoubting faith "a walking Encyclopedia." And it was a laudable peculiarity of his that he was always willing to impart information to any questioner however humble. Another peculiarity was entire self-reliance. He formed and executed his plans without consultation with any one. Sometimes those plans failed, as when, for instance he undertook to change the front of the University to the South, running the Raleigh road through the Southern part of the campus, and building a useless massive porch on the same side of Gerrard Hall. He was never heard to explain or excuse the project. He was employed to build two miles of the Raleigh road ascending the Chapel Hill promontory on the South of the Piney Prospect Hill, and when Professor afterwards Bishop Green, being made Road-overseer improved the road by a more easy ascent, the good doctor took it as a personal insult, and never forgave him. Shortly before his death, without consultation with any one he began the construction of a rock wall

into University lands, leaving the Trustees, Faculty and the public to guess at his motives. The favorite conjecture was that he designed a Botanical Garden, but there was no authority for the guess.

Let me not be understood to imply that his labors were often in vain. As Bursar, besides receiving and disbursing University moneys, he had charge of the University grounds and buildings. His success is still evident in the picturesque rock walls around the campus, the roads he built and other improvements.

Dr. Mitchell published no great book but he was active with his pen. I have heretofore mentioned his Geology of North Carolina, his Chemistry, his notes on Botany, and Facts and Dates. Without attempting minute descriptions I give a list of his contributions to journals and newspapers and of his pamphlets, not heretofore mentioned.

1. Contributions on scientific subjects to Silliman's and other journals. I suggest that some student search for these and describe them.

2. Pamphlet in defence of Presbyterian tenets, in answer to Bishop Ravenscroft, the first Bishop of North Carolina.

3. Pamphlet, proving that Slavery is righteous according to Holy Scripture and sound reason.

After publishing this Dr. Mitchell revisited his birth-town and was mortified that the authorities of his Church refused to invite him to occupy its pulpit.

4. A series of letters in the Raleigh Register attacking the Report of Dr. Ebenezer Emmons on the Deep river deposits of coal. Dr. Emmons claimed that there was a valuable coal basin. Dr. Mitchell contended that the indications were only of a four feet seam, with inclinations of about 18 degrees to the surface of the earth, and that there was no evidence of a diminution of this incline. Actual working sustains Dr. Mitchell.

5. Address before the North Carolina Agricultural Society at the Fair in 1856, in which he gave much valuable information on Agricultural Chemistry.

6. Letters to the Raleigh Register in reply to General

Thomas L. Clingman, who claimed that Dr. Mitchell was never on the highest peak of the Black Mountains, but that he Clingman was the true discoverer. He caused W. D. Cooke to designate on his wall-map the highest peak as Mt. Clingman. On the death of the Doctor he gracefully surrendered his claim. It is now conceded that Dr. Mitchell was right. He is confirmed by the United States Geologic Survey of 1881-'2, the highest and final authority.

The claim of General Clingman, on account of the lapse of time since Dr. Mitchell ascended the High Peak, his ability as a controversalist, and his influence as Senator with the departments at Washington, threatened to be formidable. Dr. Mitchell determined in June 1857, to revisit the mountain, to make instrumental measurements of its highest peak and to obtain the evidence of those who had accompanied him when he made his first ascent. With charasteristic self-reliance on the 27th of June, he left his party at the Patton House on the Southern flank of the mountains intending to journey to the top, and then go down to the settlement on Caney river in order to interview Big Tom Wilson and others, who knew about his former visits. A heavy rain detained him on the Peak and alone and in darkness the brave but rash old man attempted to descend the slippery banks of the Cat-tail fork of Caney river, along which there was no path, through thick laurels and over steep and slippery rocks. In attempting to pass around a waterfall, he slipped down a cliff forty-five feet and then fell over a precipice fifteen feet into the pool below. His watch was stopped at nineteen minutes past eight on the 27th of June, 1857. The body was found after a lengthened search 8th July, mainly by the woodcraft of Big Tom Wilson. Zebulon B. Vance, afterwards Governor and Senator, was one of the most active of the searching party. The body was not bruised and it was evident that being stunned by the fall he died painlessly by drowning.

At the request of the family he was buried in Asheville on the 10th of July, a touching sermon being preached by Rev. Robert Hett Chapman, D. D., a son of the second President of the University of the same name.

On the 14th June, 1858, at the request of many of his friends the body was exhumed and reburied on the highest peak of the Black Mountains on the 16th of the same month. A sermon was delivered by the Episcopal Bishop of Tennessee, a graduate and Tutor of the University in 1820-'21, Rev. James Hervey Otey, D. D. After him President D. L. Swain made a "Vindication of the propriety of giving the name of Mitchell to the Peak." Both sermon and address were repeated in Asheville two days afterwards.

For years the grave was marked by a cairn of stones gathered in its neighborhood. The title of the acre of land around it was vested in the University of North Carolina. On August 18, 1888 by means of a bequest of the youngest daughter of Dr. Mitchell, Mrs. Eliza North, widow of Richard S. Grant, supplemented by minor donations, the present monument of white bronze was erected on the summit. It is universally regretted that within a few weeks this monument was blown down and ruined by a tornado.

The trail to the summit, including ten miles, was in such condition that it required the labor of fourteen men thirty nine days to make it passable. The sections of the monument were transported on men's shoulders, the whole weighing about nine hundred pounds. The base is formed of two blocks of gneiss bedded together with Portland cement. The work was accomplished at the request of the University Faculty by the unparallelled energy and labor of Dr. Wm. B. Phillips, once Professor of Mining an dMetallurgy in the University of North Carolina, now Professor of Geology in the University of Texas.

I have given my opinion of Dr. Mitchell as a preacher and teacher. As a man, in social life and as a citizen, he had conspicuous virtues. He was charitable in deed and in speech. He seldom spoke harshly of anyone, even under provocation. His advice and his purse were open to the humblest. His acts of charity, very frequent, were known only from the recipients. In his controversies, he refrained from angry words and attacking motives. Notwithstanding his superiority in learning there was no ostentation. Although he preferred to be alone

with his books, his pen, or his thoughts, when in company he was agreeable and jovial—some of his jokes, according to the fashion of his youth, more coarse than suits modern taste. He was eminently kind to his family and slaves, often teaching his children, so that they were unusually well grounded in literature and science. On the whole he was looked up to and beloved by all who met him, whether casually or intimately. No one who shook his hand but thought *a great man!* In the world centers of science and scholarship he would have been among the greatest.

CHAPEL HILL, N. C.

THE COGGINS (APPALACHIAN) GOLD MINE*

BY JOSEPH HYDE PRATT

The Coggins Mine is located in the northeastern part of Montgomery County, North Carolina, 1½ miles north of Eldorado, the nearest postoffice, and 12 miles northeast of Troy, the county-seat. The nearest railroad point is Whitney, on a branch of the Southern Railway, running from Salisbury to Norwood, a distance of about 7 miles nearly west.

A description of this mine will indicate or give the salient features of several other mines in this general district.

GEOLOGY

The country rocks of this area are composed of argillaceous slates or schists, which have probably been derived from land detritus or waste, and varying amounts of tuffaceous material. Cutting these rocks at sharp angles to their schistosity are diabase dikes, which vary from a few to 6 feet in width. The strike of the schistosity of the slates is approximately N. 42° E., and they are dipping from 75° to 80° northwest. The slates are both soft and silicified and carry quartz lenses or stringers from very small narrow ones to some that are 10 or more feet in width. These slates have very evidently been faulted, and the resulting fault line has followed pretty much the schistosity of the slates; but in some instances it has cut across this at a very sharp angle. The result of this faulting has been the formation of quartz veins referred to, and also to a general silicification of the slates. The width of the slates which have been subjected to this mineralization and silicification varies up to as much as 50 to 60 feet. Another result of the mineralization has been the introduction of considerable gold-bearing pyrite into the hands of schists or slate. Some of this pyrite occurs in minute cubes up to one-eighth of an inch in diameter. There is a decided difference in the origin of the free gold in the quartz seams or slates and that which occurs in the gold-bearing pyrite. I believe it will be found that considerable of the gold in the pyrite occurs

* Reprinted from Economic Paper No. 34, of the North Carolina Geological and Economic Survey, pp. 49-59.

as free gold, and not in chemical combination with the iron sulphide or as a gold sulphide. Specimens were found in which free gold occurred in perfectly fresh pyrite. The gold runs out into very minute cracks in the pyrite, so that it is impossible to crush the ore fine enough to liberate all this gold without causing slimes. For this reason all the free gold cannot be saved by amalgamation.

The veins have a lenticular structure, as observed in horizontal and vertical planes, varying very widely in width, both along the strike and dip, and are separated by bands of schists or slates from other similar quartz veins. The ore body of this band of mineralized slate can readily be divided into two types: one consisting of numerous very narrow stringers of quartz, lying along the planes of schistosity of the rock, and which are separated from each other by narrow bands of slate which contain more or less pyrite, but which are not very silicified; and the other type containing larger masses of quartz occurring in veins or seams, and the slates inclosing them are silicified to a much greater extent.

There is great variation in the values carried by these ore deposits, and there seem to be well-defined ore shoots which also have a lenticular structure and which are richer than the balance of the vein. In some instances the foot and hanging walls are well defined, but in many cases the walls of the vein could only be determined by assaying the ore to determine to what extent the vein could be profitably worked. To one who is unfamiliar with this formation it is often very difficult to distinguish between the rich and lean portions of the vein. It is absolutely necessary in working this type of deposit to constantly sample the ore to determine its value, and the position of the vein for ore seams.

Diabase dikes have been observed cutting the schists and ore deposits, but they have been intruded subsequent to the formation of the ore, and it must have faulted or displaced the ore deposits but very little.

Three diabase dikes have been observed, two of which were exposed in the underground workings and the third at the extreme end of the "mine tract" in an open pit.

MINERALOGICAL CHARACTER OF THE ORE

The ore consists principally of free gold, with some pyrite and a gangue of white quartz or silicified slate, or both. The pyrite seems to be more or less disseminated through the schists and carries some gold, which it is believed is largely in the free state. The seams of slate that occur in the vein are also impregnated with small particles and crystals of pyrite, although their gold content is often very low. These barren portions vary in width from a few inches to several feet.

A small amount of calcite has been observed in the quartz seams, and a very small amount of arsenopyrite.

The veins are altered usually to a depth of 50 to 70 feet, but in some instances they are partly altered to a still greater depth.

VEINS.—There are two so-called veins that have been developed: one known as the "East Vein" and the other known as the "West Vein"; but as far as can be determined, these two are parts of one general ore formation and do not represent two distinct depositions of ore. The two bands of slate impregnated with the quartz veins and seams were supposed to be separated by a band of barren slate, but it was found upon sampling this that it carried a certain amount of gold.

DEVELOPMENT WORK.—The property has been developed principally by one shaft, with its drifts and cross-cuts. A certain amount of prospecting has been done at other points along the strike of the slates. At the southwest end of the property in a line S. 42° W. from the shaft, a pit (A) about 8 feet deep was sunk along the edge of a diabase dike. At several points between this pit and the shaft, several crosscuts were made, exposing the slates, but it did not show any mineral of value. To the northeast of the shaft, several pits have been made, the principal one being about 400 feet from the shaft, where a pit (B) was sunk 12 or 15 feet, that exposed the slates. This pit was approximately N. 42° E. from the shaft.

The main shaft was sunk vertically for a distance of about 8 feet, and then was turned, following approximately the dip of the slates; and is continued on this incline to the lowest level,

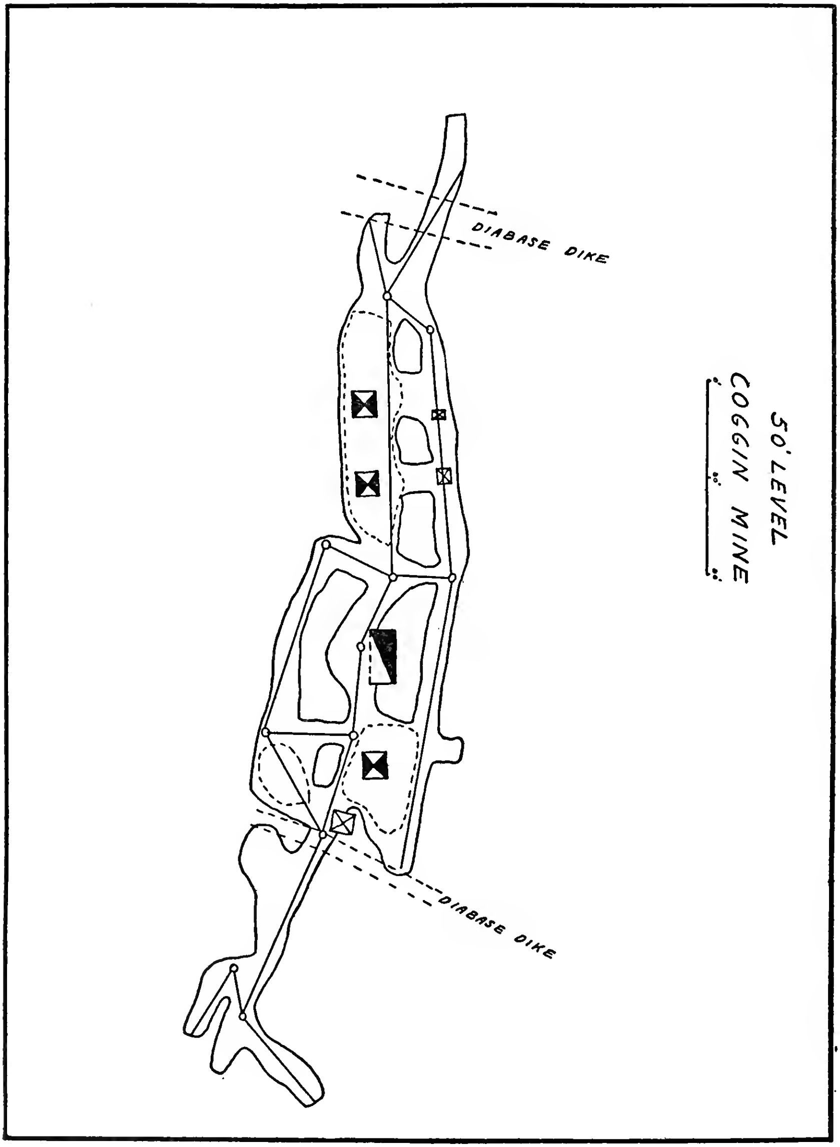


Figure 1

approximately 260 feet. Four levels have been developed from the shaft: one known as the "50-foot Level," which is approximately 57 feet from the collar of the shaft. Another level known as the "100-foot Level," a third known as the "200-foot Level," and a fourth known as "250-foot Level."

50-*foot Level.*—On the 50-foot level development work has been extended for a distance of 142 feet to the southwest of the shaft and 172 feet to the northeast of the shaft. At a point 60 feet southwest of the shaft, a diabase dike was encountered; and 130 feet northwest of the shaft another diabase dike was encountered. (Fig. 1, p. 168.) Most of the work on the 50-foot level has been stoping of ore that existed between these two dikes; and the ore has been taken out very largely from this level to the 100-foot level, also to a considerable extent from this level toward the surface. (Fig. 2, p. 171.) Blocks and pillars of ore have been left, some of which carry good values, but have not been reckoned as a part of the ore in sight. There seem to be two veins of ore, separated by a block of slate that carries considerably less value than the veins; but, as tested in certain places, carry pay values. At the extreme northeast of the drift of this 50-foot level the slates were tested, which show no free gold; and this indicates that beyond the diabase dike on the northeast there is but little ore, unless it should be found that the ore-bearing portion of this slate has been faulted. To the southwest of the southwest dike ore was encountered and stoped for a distance of about 30 to 40 feet. The extreme southwest end of the drift was tested, which showed a certain amount of free gold; indication that the ore body was continuous in this direction. The 50-foot level is connected with the surface by an upraise of 50 feet to the southwest of the shaft, and with another of 60 feet to the northeast. It is also connected with the 100-foot level by a winze from the stope to the southwest and a stope to the northeast of the shaft. (See plan of level, Fig. 2, p. 171.)

100-*foot Level.*—On the 100-foot level development work has been extended for a distance of 60 feet to the southwest of the shaft and 102 feet to the northeast. Besides the stoping that

was done from this level toward the 50-foot level, considerable underhand stoping has been done to the northeast of the shaft; and a winze has been sunk from this stope to the 200-foot level. The ore as exposed on this level was very carefully sampled, so that a comprehensive idea can be obtained of the occurrence of the ore bodies. There seems to be two ore shoots to the northeast of the shaft, separated from each other by a band of slate, which, however, is gold-bearing, as indicated by the two samples assayed, which showed $2.11 and $2.51 value in gold. The southwest ore body has been developed by a drift and cross-cut, and the ore as exposed was carefully sampled. This gave a value of approximately $9 per ton, for a width of approximately 20 feet. The work to the southwest of the shaft is apparently in the barren or partially barren band of slates, separating the two ore shoots, which accounts for the low values obtained from the assaying of the slates in the vicinity of the shaft. The southwest stope of this 100-foot level, which comes within 12 feet of this level, encountered on the southwest the diabase dike, which accounts for the stoping being stopped in that direction. The cross-cut was extended to the southwest from the winze connecting this stope with the 100-foot level for a distance of 45 feet; and then another drift was extended for about 30 feet to the southwest, cutting through the diabase dike. A sample was taken of the supposed ore just beyond the dike, but this showed but very little value. (See plan of level, Fig. 3, p. 172.)

200-*foot Level.*—On the 200-foot level development work has been extended for a distance of 90 feet to the southwest and 120 feet to the northeast, and the ores have been stoped at two points: one at the extreme southwestern portion of the level and the other about 20 feet from the extreme northeastern portion of the level. Both overhead and underhand stoping have been done. Neither of these stopes connect with the 100-foot level; but a connection with the 100-foot level is had by the winze sunk from the northeast stope of the 100-foot level to a cross-cut on the 200-foot level, which is to the southeast of the stope. The development work on this 200-foot level indicates that the so-called "two-ore bodies" of the 50- and 100-foot levels

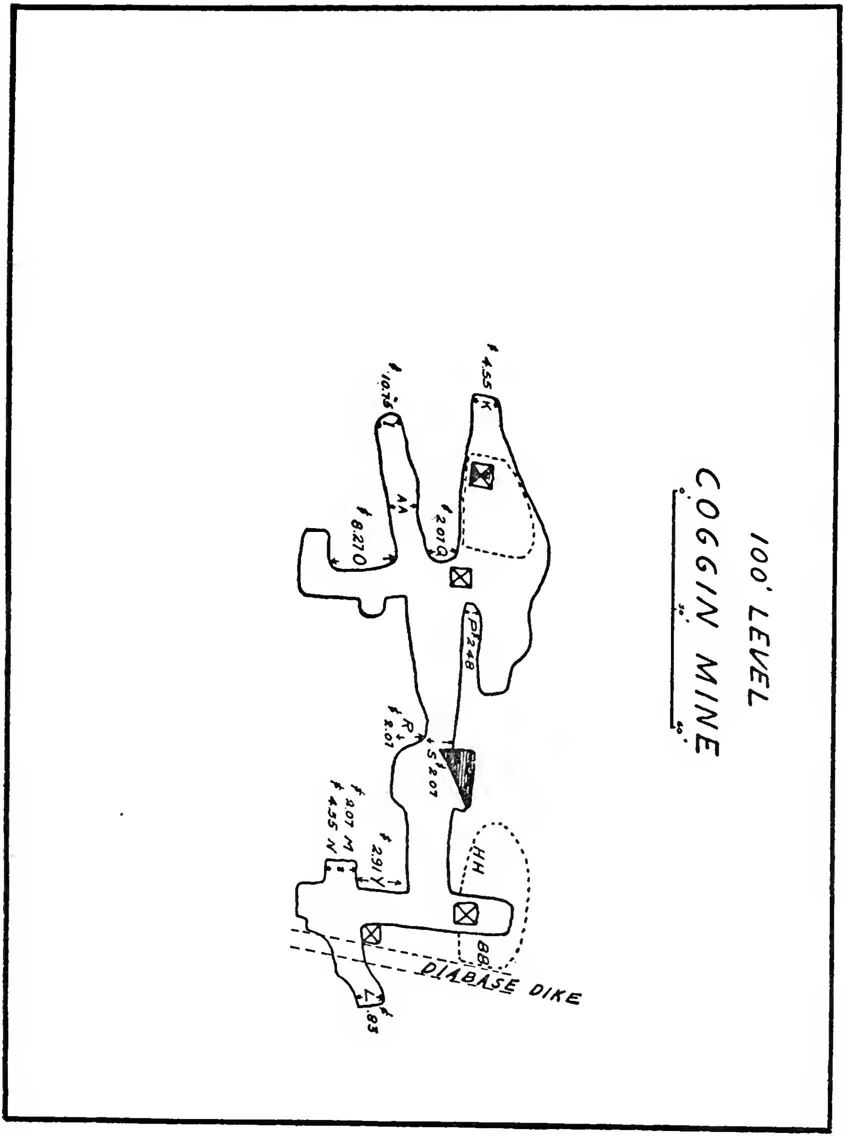


Figure 2

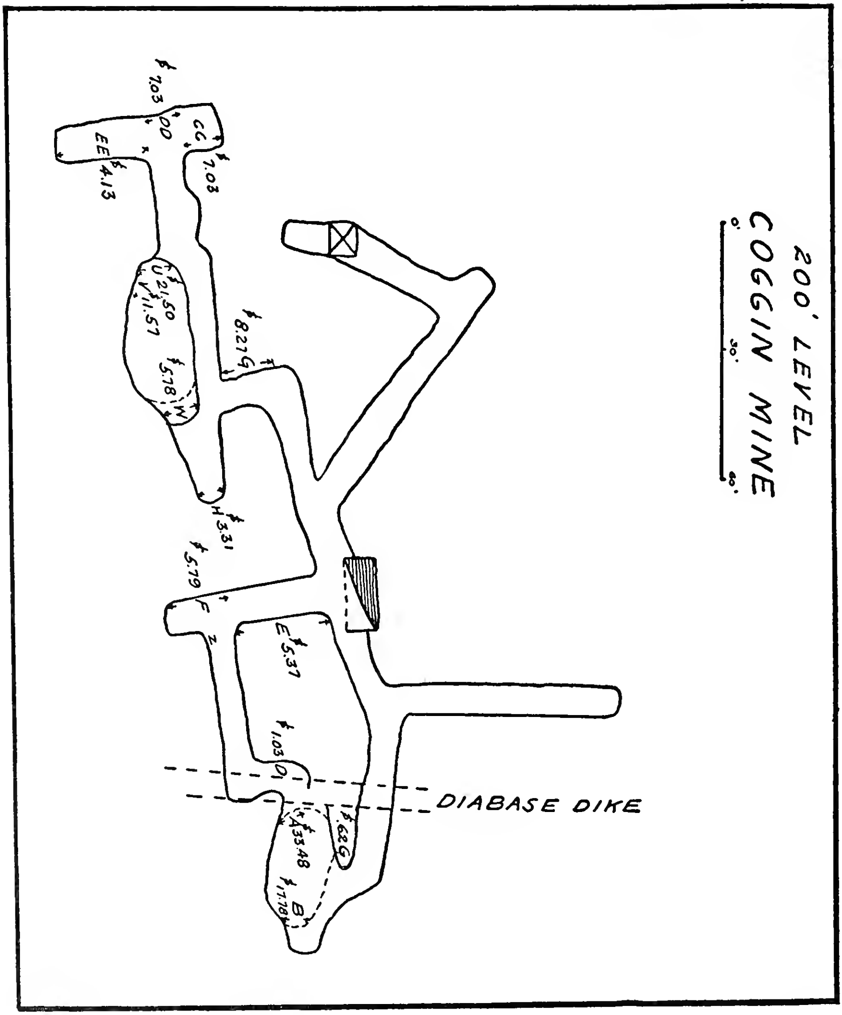


Figure 3

have come together on this 200-foot level. As assayed, an ore body is developed on this level 42 feet wide at the northeast portion of the level, which carries values of approximately \$6 per ton for the whole width. The northeast stope is on the richer ore shoot that occurs in the vein, and has been stoped for a width of about 15 feet. The assays made of this ore shoot showed values varying from \$5.82 to \$21.54 per ton. The southwest stope of this level is on the richer portion of the ore body, just southwest of the diabase dike, and showed values of \$17.82 and \$32.52 per ton. This stope is about 12 feet wide. Between these two stopes, a distance of approximately 90 feet, there is a block of ore that has been developed by means of cross-cuts, that gave values varying from \$3.38 to \$8.30. There is apparently a seam of slate in this ore body that carries very low values. The whole body of ore, approximately 40 feet in width, will be found to carry approximately \$5.50 to \$6 per ton. The ore shoot to the southwest undoubtedly extends further to the southwest than has been developed.

It was impossible to get down into certain of the stopes in order to take samples at the bottom of the stopes between the 100- and 200-foot levels, and also the upper portions of the stopes from the 200-foot level. Two sides, however, of the block of ore between these two levels have been sampled and assayed, which will give an approximate value of the ore body; and this value has been used in reckoning the ore body.

250-*foot Level.*—At the 250-foot level a drift has been run a distance of 47 feet, N. 50° W. At a distance of 37 feet drifts were started northeast and southwest on a rich vein or seam of ore. As assayed, this seam carried from \$170 to \$232 in gold. Portions of it were rich, one 2-foot sample assaying \$677 per ton. The material taken out of this cross-cut and the drifts show ore delivered to the mill on my last visit to the mine, January, 1914. The drifts from this cross-cut had only been extended a distance of 6 or 8 feet. A winze was started from the northeast stope of the 200-foot level to connect with the northeast drift on the 250-foot level. On account, however, of the difficulty in keeping good air in the winze, work was stopped on this, and an upraise will be made from the 200-foot level to connect with this winze.

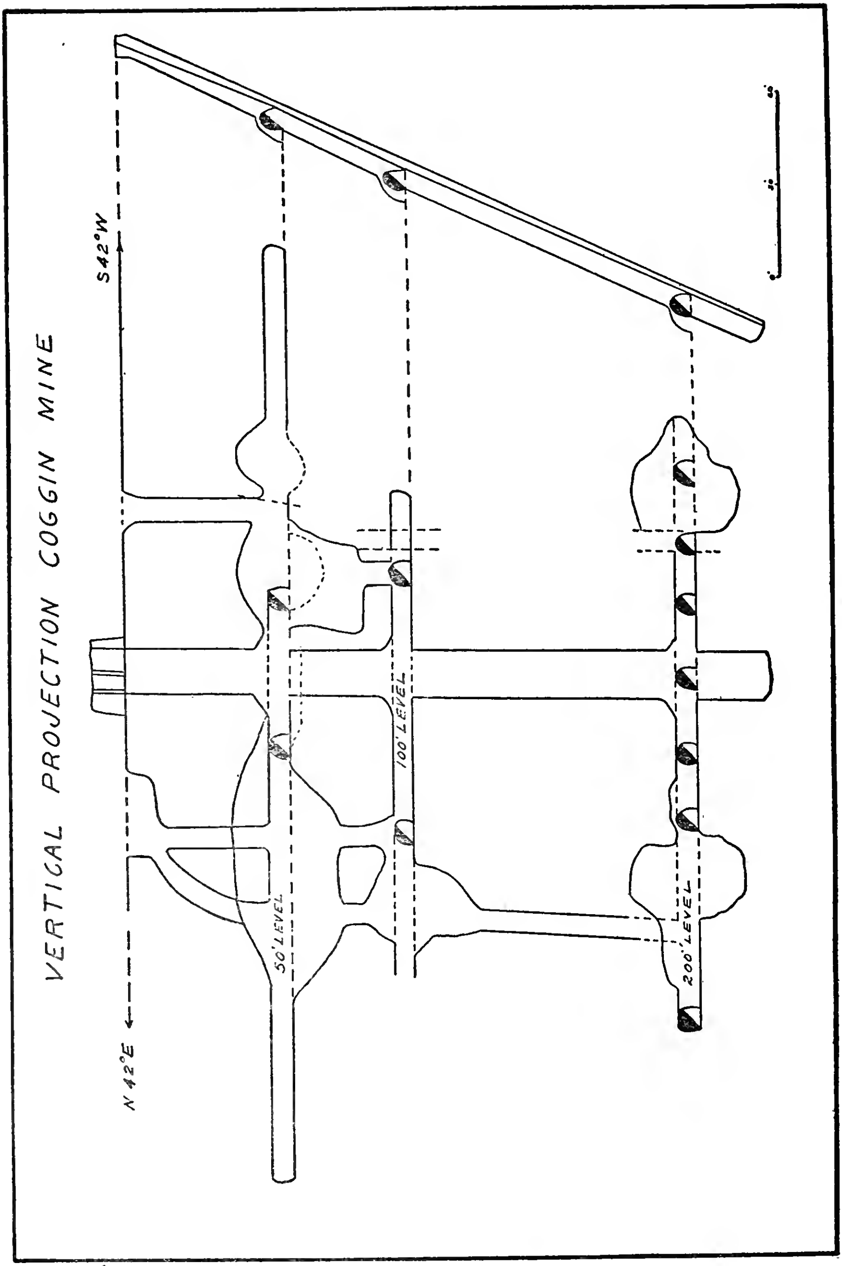

VERTICAL PROJECTION COGGIN MINE
S 42° W
N 42° E
50' LEVEL
100' LEVEL
200' LEVEL

Figure 4

The percentage of free gold in the ore at the 250-foot level is approximately the same as at the 200- and 100-foot levels. It is very interesting to note, and indicates that this type of ore is carrying free gold to considerably greater depth than had been expected.

Northeast Pit.—This pit, which is about 400 feet N. 42° E. from the main shaft, is 13 x 13 feet, and has been sunk to a depth of approximately 15 feet. This pit exposed the slates which, for a width of 6 feet, contained numerous seams and veins of quartz. The strike of the slates was approximately the same as that at the shaft, and their dipping, if anything, a little more vertical. All the slates were badly decomposed to the depth of the pit. A sample was taken from across the width of this open pit, and upon panning showed considerable free gold.

Southwest Pit.—This pit, which is at the extreme southwest portion of the 62-acre tract, has been sunk to a depth of about 6 to 8 feet alongside of a diabase dike. The strike of the schists that were exposed is approximately N. 43° E., and the strike of the dike approximately N. 20 to 30° E. A sample was taken of the slates as exposed in the pit just to the northeast of the dike; but, upon panning, this did not show any free gold, although some pyrite.

ASSAYS OF GOLD ORE, COGGINS MINE

Sample	Level	Description	Width	Value in Gold
A	200 ft.	Southwest stope	6 ft. 6 in.	$ 33.48
B	200 ft.	Southwest stope opposite end from A	5 ft. 10 in.	17.78
C	200 ft.	Just east stope, supposed wall rock	2 ft. 3 in.	.62
D	200 ft.	Just northeast of dike. All slate	10 ft.	1.03
E	200 ft.	West cross-cut from shaft. Mostly slate with seams of quartz	17 ft.	5.37
F	200 ft.	Last 12 ft. cross-cut. Northeast side	12 ft.	5.79
G	200 ft.	Cross-cut to northeast stope. Section east of stope	11 ft. 6 in.	8.27
H	200 ft.	Extreme southwest end of northeast stope	4 ft. 7 in.	3.31
I	100 ft.	Extreme end. Almost western to the northeast drifts	4 ft. 6 in.	10.75
K	100 ft.	Extreme end of the easterly northeast drift	5 ft. 10 in.	4.55
L	100 ft.	Extreme southwest end just beyond diabase dike	4 ft.	.83
M	100 ft.	Southwest cross-cut. Slate 3ft. 3in.	3 ft. 3 in.	2.07
N	100 ft.	Next 5 ft. 8 in. beyond M	5 ft. 8 in.	4.55
O	100 ft.	Northeast cross-cut. Northeast side	9 ft.	8.27
P	100 ft.	Southwest end of northeast stope	6 ft. 2 in.	2.48
Q	100 ft.	Junction of two northeast drifts	8 ft. 5 in.	2.07
R	100 ft.	Just east of main shaft. Northeast side of chamber	9 ft. 6 in.	2.07
S	100 ft.	Nine ft. to the east of R, extending partly beyond shaft	9 ft.	2.07
T	100 ft.	2 ft. seam of quartz of S	2 ft.	1.65
U	200 ft.	5 ft. above bottom northeast stope, northeast end	5 ft. 10 in.	21.50
V	200 ft.	Just southwest U, 3 ft. to 4 ft. above bottom of stope	3 ft. 5 in.	11.57
W	200 ft.	Southwest end of stope. 3 ft. above bottom	8ft. 11 in.	5.78
Y	100 ft.	Southwest cross-cut. Northeast side of first 8 ft. of slate	8 ft.	2.91
AA	200 ft.	Westwardly northeast drift. 31 ft. 6 in. from face. Sample across roof	12 ft. 10 in.	10.33
CC	200 ft.	Extreme northeast cross-cut. East section	14 ft. 8 in.	7.03
DD	200 ft.	Same as CC. Next 10 ft. 10 in. to west	10 ft. 10 in.	7.03
EE*	200 ft.	Next 16 ft. 10 in. to DD to west	10 ft. 10 in.	4.13
A-2†	250 ft.	North side of cross-cut, 33 ft. from shaft	8 ft.	232.68
B-2	250 ft.	South side of cross-cut, beginning 33 ft. from shaft	8 ft.	171.51
C-2	250 ft.	South side of cross-cut, beginning 33 ft. from shaft	2 ft.	12.64
D-2	250 ft.	Next 2 ft. to C-2	2 ft.	218.99
E-2	250 ft.	Next 2 ft. to D-2	2 ft.	677.59
F-2	250 ft.	Next 3 ft. to E-2	3 ft.	70.38
G-2	250 ft.	North side cross-cut, beginning 33 ft. from shaft	3 ft.	258.90
H-2	250 ft.	Next 2 ft. to G-2	2 ft.	73.79
I-2	250 ft.	Next 2 ft. to H-2	2 ft.	10.02
J-2	250 ft.	Next 2 ft. to I-2	2 ft.	3.08
K-2‡	250 ft.	South side of cross-cut, last 3 ft. 2 in. of cross-cut	3 ft. 2 in.	1.26
L-2‡	250 ft.	Next 1 ft. 6 in. to K-2	1 ft. 6 in.	1.44

* Assays A to EE were made by Mr. Frank Drane, Charlotte, N. C.

† Assays A-2 to L-2 were made by Mr. Henry McCoy, Ophir, N. C.

‡ It was considered when these two samples were taken that they were beyond the ore-bearing seam, and the assays indicate this.

The ore bodies exposed in the Coggins Mine were carefully sampled and the location from which the samples were taken indicated by letters on the maps. (Figs. 2 and 3, pp. 171 and 172.)

In addition to the above samples, several other samples were taken, which were panned to determine whether or not the ore tested was carrying free gold, and the relative amounts. The panning samples were quartered and the amount panned usually weighed from 1 to 3 pounds. These samples were taken as follows:

Sample	Level	Description	Width	Value in Gold
Z	200 ft.	Quartz seam in drift from cross-cut in front of shaft.	2 ft.	Showed several nuggets of gold ¼ dwt. to 1 dwt. and many colors
BB	100 ft.	Southwest end of southwest stope. Material next to diabase dike.	2 ft.	Showed 3 good colors and many minute ones.
GG	100 ft.	Overhead southwest stope. Sample taken next to diabase dike.	9 ft.	Showed one good color, several minute ones. Several pyrite.
HH	100 ft.	Northeast portion of southwest stope to quartz seams.	2 ft.	Showed two fair colors and considerable fine gold
II	50 ft.	Extreme southwest end		Showed several small colors, some pyrite.
MM	50 ft.	Extreme northeast end beyond diabase dike.	4 ft. 10 in.	Showed no free gold. Some pyrite.
OO	50 ft.	Just southwest of diabase dike of southwest drift. Siliceous slate.	6 ft. 7 in.	Showed fair colors and many minute ones. Some pyrite.
PP	Surface	Pitt B	3 ft.	Many colors.
OO	Surface	Pitt A	3 ft.	No gold.
XX	200 ft.	Northeast stope sample taken from material left on supposed hanging hall.	10 ft.	Nine fair colors. Many minute ones. Some pyrite.

A 10-stamp mill with four sets of amalgamation plates and two Wilfley concentrating tables has been erected. The ore as it is brought from the mine is raised to a hopper, from which it is fed to a Gates crusher, which feeds it onto an endless belt. This conveys the ore to the hopper, which feeds to the stamp mill. The capacity of the mill is approximately 30 tons per day.

There seems to be but very little tendency for the ore to slime, and a very good separation is obtained. One run of ore

from the winze that was being sunk from the 200-foot to the 250-foot level, which gave $19.75 on assaying, gave tailings assaying 90 cents. The ore from the 200-foot level, as it was delivered to the mill, asayed $53.20. Tailings from this ore assayed $4.35 on the first run. On the second run, where the ore assayed $54.02, the value of the tailings had been cut down to $2.88. The concentrates from the first run gave values of $133.03, and on the second run, $81.57. This, of course, is accounted for by the fact that the concentrates were not as clean as in the first run. The concentrates were carefully tested by panning, but showed no free gold. This was also true of the tailings, which indicates that there is a very complete amalgamation of free gold on the plates. The fineness of the Coggins gold, as determined in the Laboratory, was 904.

CHAPEL HILL, N. C.

CERTAIN MAGNETIC IRON ORES OF ASHE COUNTY*

BY JOSEPH HYDE PRATT

During the past six months the author has had the opportunity of examining several of the magnetic iron ore deposits of Ashe County, and to study in considerable detail their occurrence and the geology of the districts.

The deposits examined are located in the northeastern portion of Ashe County, principally along the north fork of New River and its tributaries that flow into it from the north. The deposits can readily be divided into three belts: one known as the "River Belt," another the "Poison Branch Belt," and the third, "The Helton Creek Belt."

While formerly these deposits were twenty or more miles from the railroad, the one now being built across Ashe County will bring the Ballou-Piney Creek, the Joseph Graybeal and Waughbank properties within a very short distance of the railroad.

These ores are all magnetic iron ores, occurring in crystalline rocks which consist principally of hornblende gneisses and schists and micaceous schists. The deposits of ore are undoubtedly lenticular or lens-shaped, and are pinching and widening in all dimensions. These lenses may continue for long distances along the strike and on the dip; then, again, there may be a series of smaller lenses separated from each other by country rock or connected with each other by a thin seam of ore. Sometimes they may be so small as to be of no commercial value; while at other times they attain enormous size, both in length and depth. Usually these ore deposits are conformable to the enclosing country rock. Each ore locality has to be investigated as a separate unit, inasmuch as there is great variation in them, and it does not follow that because one ore deposit is well developed that another one, even in the same belt, will be equally as good. These lenses have a general northeast-southwest trend.

The deposits examined include the Calloway and W. H.

* Reprinted from Economic Paper No. 34, of the North Carolina Geological and Economic Survey, pp. 65-73.

Brown properties of the "River Belt"; the Waughbank, the Graybeal, the Ballou-Piney Creek, Francis, McClure, Poison Branch, Falls, and Red Hill properties of the "Poison Branch Belt"; and the Kirby and Sturgill properties of the "Helton Creek Belt."

RIVER BELT

The principal property examined in this belt is known as the Calloway property, the mineral interest of which is owned by Mr. Uriah Ballou. It adjoins a portion of the old N. B. Ballou property, the mineral interest of which is now owned by the Virginia Iron, Coal and Coke Company. The iron ore outcrops at the top of the hill, and has been developed by means of cuts and tunnels, so that the ore is exposed at various points from the top of the hill to the creek, 150 feet or more below. The principal development work on the Calloway property is a tunnel that was started about 140 feet below the top of the hill. This tunnel was extended in a N. 35° E. direction for a distance of 103 feet, when it encountered the iron ore. A cross-cut was made in order to determine the width of the ore, and it exposed a width along the cross-cut of 27 feet 8 inches, which would give a width across the vein of about 20 feet. The strike of the vein is approximately N. 45° E. The cross-cut, after penetrating the ore, was turned N. 70° E., and then 60° west, following the hanging wall until it again encountered the ore, which it followed for a distance of 17 feet 8 inches without penetrating the ore body. This gave a horizontal distance of about 30 feet along the vein. This same ore body outcrops at the surface at several places between this level and the top of the hill. By means of float and a few cross-cuts this ore belt can be traced in a southwesterly direction for a distance of about a mile across what is known as the Davis property and the Neaves property, when it crosses the north fork of New River. The deposit narrowed considerably, but where it crosses the river it is reported to have a width of 12 feet. On the Calloway property it is estimated that there is a distance of 450 feet of the vein from the tunnel to where it crosses onto the property owned by the Virginia Iron, Coal and Coke Company. Average samples of the ore as exposed in the tunnel were taken across the vein, where

cut by the cross-cuts. Results are given in analyses I and II of Table of Analyses.

The ore is very much mixed with gangue, but the magnetite can readily be separated from the gangue and largely concentrated by hand cobbing.

On the side of the hill controlled by the Virginia Iron, Coal and Coke Company sufficient crosscuts and tunnels have been made to show that the vein is continuous across the property.

POISON BRANCH BELT

The first property examined in this belt is known as the Poison Branch mine, the mineral interest of which is owned by Mr. Uriah Ballou and Mrs. Davis. The ore was encountered near the summit of a hill dividing the waters of Old Field and Silas creeks. Considerable work has been done on this property, part of which was to obtain ore for an old Catalan forge. This ore was obtained from two open cuts on the northeast side of the road, one on each side of the divide. Fifty feet below the summit a tunnel 181 feet in length was run into the hill, from which crosscuts were made: one at the extreme end of the tunnel; another 45 feet towards its mouth; and a third 114 feet from the end. The strike of the vein is approximately N. 40° E., and the dip about 45° S. E. Both the first two cuts cut across the vein for a distance of a little over 9 feet, which would give a vein of an actual width of 4½ to 5 feet. A third crosscut was run for a distance of over 33 feet, but this was as far as it could be entered at the present time, as it had been filled up with waste material from some other part of the mine. No ore could be seen in this crosscut. Average samples of this ore were taken, and the results are given under III in the Table of Analyses beyond.

The foot wall of this deposit is a mica schist, while the hanging wall is a hornblende gneiss.

This ore belt has been traced in a southwest direction from the Poison Branch property for a distance of about 3½ miles crossing the McClure, Blevins or Falls, Uriah and Graybeal properties. It is questionable whether the deposit itself is continuous, and it is more than apt to be made up of lenses of

magnetite, which may or may not be connected with each other. With the exception of the McClure property, the ore was observed in place on all of the properties. On this property, however, the cuts had become filled up so that no ore at all was exposed. Previous investigations, however, made by Mr. H. B. C. Nitze of the State Geological Survey showed conclusively the continuation of the magnetic iron ore belt across this property.

The Falls or Blevins Property.—This property, which was formerly known as G. Douglas Blevins property, is now owned and controlled by B. G. Falls and Charles Blevins, and is about 3 to 4 miles southwest of the McClure. The ore is exposed in a vein which outcrops in a ledge above Mr. Falls' house. The ore is a hard magnetite occurring in an epidote gneiss. There is also considerable of the epidote occurring as a gangue with the magnetite. An assay of this ore gave 43.29 per cent of iron. The vein as exposed on the outcrop of the ridge is about 8 feet wide. The strike is approximately N. 50° E., and the dip about 45° to the southeast. About 60 feet below the summit of the ridge a tunnel was run 60 feet into the hill, which cut but did not penetrate the vein. To the northeast of the vein on the same property there is another occurrence of magnetite that outcrops on the W. Jones property.

Ballou-Piney Creek Property.—About half a mile south, a little west of the Falls property, there is an occurrence of manganiferous magnetite on the Uriah Ballou land just above the waters of Piney Creek, about 1½ miles from it mouth. An open cut has been made here just below the road, which exposed 18 feet of ore, which would make the vein 12 feet across. The ore is very coarse grained, very free from gangue, but containing near its center a 15-inch seam or vein of soft brownish-black manganese-iron oxide. This ore was sampled and the analysis showed 64.56 per cent of metallic iron. For complete analysis see VI of table below. The soft brown ore was also analyzed, showing 42.80 per cent of metallic iron. See analysis VII in Table of Analyses.

About 85 feet above the cut described above the ore was exposed in a cut 4 to 5 feet deep. A granular ore, similar to the above, was found. The full width of the vein was not ex-

posed. A sample of this ore gave 65.50 per cent of metallic iron. See analysis V of table. About 40 feet still higher on the hill another cut 3 feet deep also exposed the same kind of ore. The lateral distance represented by the exposures made in the three cuts mentioned above is approximately 350 feet. The lead has been traced by means of float for a considerable distance beyond that exposed in the upper cut. The above all indicates that there is a lens of very large size on this property.

Ballou's Horse Creek, or Waughbank Property.—This property is about 1½ miles southwest of the Ballou-Piney Creek property on the north bank of Horse Creek. About 100 yards from the creek a tunnel was run by the Pennsylvania Steel Company. The tunnel has a direction of N. 40° E., and at a distance of 100 feet a crosscut was made extending 46 feet S. 40° W.

This crosscut showed ore for its whole distance, making the width of the ore deposit over 30 feet. This ore is composed of coarse granular magnetite in a matrix composed of micaceous material and manganese oxide. A rough estimate indicates that about 70 per cent of the ore body would represent the iron ore. This material was sampled and the results of the analysis are given in VIII-A in the table beyond. This mineral can readily be cobbed, which will raise the iron content. A sample was also analyzed of the magnetic iron portions of the vein, which gave 67.25 per cent of iron. The results of this analysis are given in VIII of the Table of Analyses.

Seventy-five to one hundred feet above the tunnel the vein was exposed in an open cut; but, on account of the cut having caved in, nothing definite could be determined in regard to the width of the vein.

Graybeal Property.—About one-half a mile northeast of the Waughbank property begins what is known as the Graybeal properties. The first property encountered is the Calvin Graybeal. Only a very little development work has been done on this property, but float ore has been encountered, which would indicate the continuation of the ore formation across the property.

A short distance north from the top of the hill on the Cal-

vin Graybeal property on lands owned by the Patton family and Calvin Graybeal, a cut exposed magnetic iron ore mixed somewhat with the country schist. This may be part of an ore deposit that is known in that section as the "North vein," which extends approximately parallel with the regular ore formation, and approximately 200 to 300 yards north of the larger vein.

It is about one-fourth mile from the top of the Calvin Graybeal hill to the Joseph Graybeal property in a general northeast direction. The vein has a strike across this property of an approximately northeast direction, and it is dipping toward the southeast. The ore deposit has been prospected and developed by means of open cuts, pits, and tunnels for a lateral distance of at least 800 feet and a vertical distance of over 100 feet. A drill hole was made by the Pulaski Iron Company at a point about 700′ to the southeast of the first open cut, and 75′ below. It is reported to have encountered the ore at a depth of about 200′. The dip of the vein would bring the ore body to this point. The width of the ore body as encountered varied from 4 to 15 feet.

The first cut examined was partially filled, so that the extent of the vein could not be determined. Good ore is exposed in the cut, thus showing the continuance of the ore body. This work was done by the Virginia Iron, Coal and Coke Company in 1907. Three hundred feet to the northeast another cut exposed the vein, which had a width of at least 15 feet of nearly solid ore, there being a little of the ore mixed with finely divided gangue rock. An analysis of this ore showed 63.50 per cent metallic iron. At the mouth of the cut, about 30 feet from the vein, another small seam of ore 12 to 15 inches thick was exposed. Most of this work was done about 1890 or 1892. Part of it was done in the early days of iron mining in the county, when the ore was obtained for Catalan forges.

Still further to the northeast a long open cut or trench was made by Mr. Sturgill in 1903 across the ore deposit. At the time of my visit, however, it was nearly all filled up, and the ore was only exposed at the east end of the cut.

Float ore has been found between all the cuts referred to.

On the opposite side of the hill several cuts and tunnels have

been run which penetrated the ore body, showing that the ore was continuous through this hill. Most of the work was done by the Virginia Iron, Coal and Coke Company in 1907. The first cut is about 300 yards northeast of the Sturgill cut referred to above. The first work done at this cut was in the early days to obtain ore for Catalan forges. Near the mouth of the cut an iron manganese seam of ore was encountered 6 feet wide, the distance between the two veins being about 30 feet. This ore was analyzed, and the results are given in XIV of the Table of Analyses. Its iron content was 63.15 per cent.

Thirty feet below this cut a tunnel was run into the hill. This was partially caved, so that it could not be examined except near its mouth, where a manganese iron vein was observed. Judging from the material found on the dump, the ore encountered in the tunnel was very similar to that in the cut referred to above.

Two hundred and fifty feet northeast of this tunnel another open cut was made by Dr. Tom Jones in 1905, and work was continued by the Virginia Iron, Coal and Coke Company in 1907. This cut exposed a seam of magnetite about 4 feet wide, which it penetrated. In the uper end of the cut there was exposed a mixture of pyrite and hornblende. Thirty feet below and 30 feet northeast of this cut a tunnel was run by the Virginia Iron, Coal and Coke Company, and later continued by Dr. Jones. This penetrated the ore body. There was exposed near the mouth of the tunnel a manganese iron seam of ore.

From this point it is 300 yards northeast to the Joseph Graybeal line. Beyond this property is the Dr. Thomas Jones land which has been prospected for the whole distance along the course of the ore by means of shallow cuts and pits. Only at one or two places was the ore exposed in place.

Henninger Property.—Adjoining the Dr. Jones property on the northeast and east are the Francis and Henninger properties. About 500 feet from the Dr. Jones line a small open cut was made, which showed granular magnetic ore. Six hundred feet northeast of the first opening another open cut shows similar ore. These two cuts were made by Mr. E. Sturgill about 1903 or 1904. These openings are near the barn of Mr. Eugene Ballou, who now owns the property.

Francis Property.—This property, which is between the Henninger and the Ballou-Piney Creek properties, has been developed to some extent by means of open cuts and tunnels, but at the time of my visit no ore could be observed in place. This ore was observed in place by Mr. H. B. C. Nitze of the North Carolina Geological Survey when he made an investigation of the Ashe County iron ores.

Red Hill Property.—The Red Hill property is near the northeast extension of the Poison Branch ore belt. The Red Hill rises about 170 feet above the level of the creek, and a trench over 200 feet in length has been made from one side of the hill to the other near its summit. While it did not expose a vein of solid magnetite ore, it did show a decomposed schistose rock, which carried almost throughout its entire extent masses and particles of magnetite scattered through it. There have been many openings made at various points on the hill which encountered magnetic iron ore. In some of the cuts more or less pyrite was observed, which will have a tendency to increase the sulphur content of the ore.

HELTON CREEK BELT

Kirby Mine.—This mine is located on the upper waters of Helton Creek, about one-half mile north of Sturgill postoffice and one-fourth of a mile from Helton Creek. The ore body on this property was exposed by a series of cuts made by the Pennsylvania Steel Company in 1902. One cut about 55 feet above a small branch showed ore exposed for a distance of 17 feet. Another cut 25 feet still higher on the hill showed a similar exposure of ore. This ore was in a gangue of epidote and hornblende. On the opposite side of the branch a long open cut was made by Mr. Sturgill in 1892. The mineral interest is owned by Mr. J. L. White and Sheriff Sturgill. Analysis of the ore is given in XVI of the Table of Analyses. The iron content of 43.10 per cent can easily be increased by hand cobbing.

There is given in the table below analyses of the ores from the various properties mentioned above.

TABLE OF ANALYSES

Locality	No.	Iron	Manganese	Silica	Phosphorus	Sulphur	Titanium	Analyst
Calloway Property	I	31.26	....	17.37	.028	.10	....	Drane*
Calloway Property	II	38.36	....	....	....	....	....	Drane
Poison Branch Property	III	45.25	....	20.65	.052	1.58	trace	C. & M.†
Falls Property	IV	43.25	....	....	....	....	....	C. & M.
Ballou-Piney Creek Property, upper-cut	V	65.50	2.81	....	....	....	....	C. & M.
Ballou-Piney Creek Property, near creek	VI	64.56	2.59	2.06	.014	trace	none	Drane
Ballou-Piney Creek Property, Mn-Fe vein	VII	42.80	17.48	....	....	....	....	C. & M.
Waughbank Property	VIII	67.25	1.68	....	....	....	....	C. & M.
Waughbank Property, Magnetite	VIII-A	46.25	4.34	....	.026	.027	trace	C. & M.
Graybeal Property, first cut	XI	67.40	....	1.15	.005	.060	none	C. & M.
Graybeal Property, second cut	XII	63.50	....	....	....	....	....	C. & M.
Graybeal Property, large cut at top hill	XIV	63.15	3.58	....	....	....	....	C. & M.
Kirby Mine	XVI	43.10	....	21.76	.057	.036	trace	C. & M.

* Frank Drane, Chemist, Charlotte, N. C.

† Crowell & Murray, Chemists, Cleveland, Ohio.

As will be seen from the above analyses, there is considerable variation in the metallic contents of the ore, but the iron content is good, and as they are all comparatively low in sulphur, phosphorus, and titanium, they will, therefore, make iron ores of high value.

Analyses I and II of ore from the Calloway property are low in iron, but they represent samples taken across the full width of the ore deposit, including gangue and waste. By hand cobbing this ore can readily be raised to a 55 to 60 per cent iron ore. The magnetite portion of the vein gives as high as 65 per cent metallic iron.

The ores represented by analysis III, IV, and VIII-A can also be easily concentrated by hand cobbing.

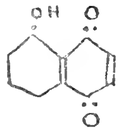
All the ores tested are a splendid grade of magnetite, and should make a pig iron of exceptional quality.

CHAPEL HILL, N. C.

THE ISOMERISM OF THE HYDROJUGLONS*

RICHARD WILLSTAETTER AND ALVIN S. WHEELER

Thanks to the splendid researches of A. Bernthsen[1] and F. Mylius,[2] the uncertainties of the constitution of juglone have been fully cleared up. The decomposition of juglone into β-hydroxyphthalic acid and its synthesis from 1, 5-dihydoxy-naphthalene indicates that its structural formula is that of 8-hydroxy-1, 4-naphthoquinone:



The study of the two hydrojuglones however remained incomplete in certain important points, especially in regard to their isomerism.

Mylius isolated two isomeric compounds, α- and β-hydrojuglone, from green walnut shells. The first, which possesses the higher melting point, is a true hydroquinone and oxidizes easily to juglone. The β-compound however does not pass directly into juglone. According to Mylius the two hydrojuglones can be converted into each other in different ways. For example, the α-form can be changed into the β-form by distillation or by the hydrolysis of its acetyl derivative. The β-form may be turned back into its isomer by heating a solution of it in alcoholic dilute hydrochloric acid. Mylius explained the relations between the two isomers as position isomerism. He stated that one of the para hydroxyl groups in the α-hydrojuglone changed its location in the nucleus of the disubstituted benzene ring. This explantion was plausible for nearly thirty years but the easy mutual transformations of the isomers are in our view opposed to this theory.

We find it is not necessary to distill the α-hydrojuglone in

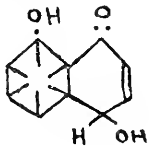
* Translated from Ber. der deutsch. chem. Gesell., 47,2796 (1914).

[1] Ber. der deutsch. chem. Gesell., 17,1945 (1884); Bernthsen and Semper, *ibid*, 18,203 (1885); 19,164 (1886), 20,934 (1887).

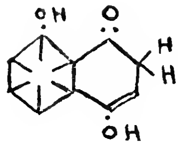
[2] Ber. der deutsch. chem. Gesell., 17,2411 (1884); 18,463,2567 (1885); also Habilitationsschrift, Freiburg i. B., 1885.

order to isomerize it. One needs only to heat until it melts in order to obtain an equilibrium out of which one can readily isolate nearly three-fourths as the β-compound. In order to convert this into the α-form it is sufficient to dissolve it in alkali with the exclusion of air and then to acidify. This is not a case of the wandering of an hydroxyl group but rather a case of keto-enol isomerism.

α-Hydrojuglone is a true trihydroxynaphthalene (1, 4, 8). Its solutions are distinguished by a very strong fluorescence. β-Hydrojuglone is the keto form of it in which one of the two hydroxyl groups in the para positions has experienced a transformation into a carbonyl group, according to one of the following formulas:



OR



We are able to support this view since we have obtained well crystallized semicarbazones of β-hydrojuglone with semicarbazine and with phenylsemicarbazine while analogous derivatives of α-hydrojuglone could not be obtained. An oxime of β-hydrojuglone was also observed but a closer study of it has not been undertaken. That the two isomers yield the same triacetyl and tribenzoyl derivatives is in agreement with this conception. But it does not well explain the behavior of these derivatives on hydrolysis. The acetyl compounds yield β-hydrojuglone by the action of strong sulfuric acid, while α-hydrojugolne according to Mylius is not transformed into its isomer by sulfuric acid.

The isomerism of the hydrojuglones is the first case if keto-enol isomerism of a phenol in the naphthalene series. It ranges itself alongside the desmotropic phenomena of the meso-phenols of the anthracene series (dianthranol, anthranol and anthrahydroquinone) which Hans Meyer[3] and especially Kurt H. Meyer[4] have described in their important investigations.

[3] Ber. der deutsch. chem. Gesell., 42,143 (1909); Monatsh., 30,165 (1909).
[4] Ann., 379,37 (1910-'11); Meyer and Sander, Ann., 396,133 (1913).

PREPARATION OF JUGLONE

We found that the oxidation of 1, 5-dihydroxynaphthalene according to Bernthsen and Semper[5] was the best method for the preparation of juglone although we were unable to secure a higher yield of the pure quinone than sixteen per cent. 1, 5-Dihydroxynaphthalene was purified by dissolving in ether and reprecipitating in petroleum ether. It forms colorless prisms which melt at 254°. 50g 1, 5-Dihydroxynaphthalene, after rubbing up with a small quantity of water, are introduced in small portions into a chromic acid mixture consisting of 240g sodium bichromate, 340g concentrated sulfuric acid and 3400cc water. The temperature is not allowed to rise above 10°. On the following day the brownish yellow precipitate is filtered off, dried and boiled up with ligroin, 70-80°. The impurities remain undissolved and the extracts upon concentration yield 8.8g juglone in the form of deep yellow needles. They show a melting point of 149-50°, when the substance is introduced into a bath previously warmed to 140°.

We found that juglone could also be obtained from 1, 5-dihydroxynaphthalene by oxidation with lead peroxide. The yield is somewhat higher but the process is not practical. It is noteworthy how much the yield here depends upon the quantity of the solvent and of the oxidant on the surface of which the oxidation takes place. 100g Lead peroxide in one liter of benzene yields the same quantity of juglone whether 5g or 0.5 g dihydroxynaphthalene are used. 0.5g 1, 5-Dihydroxynaphthalene are boiled five hours in one liter of benzene with 100g good lead peroxide. The beautiful yellow solution is concentrated in vacuum to 10cc and mixed with petroleum ether. 0.15g Juglone crystallizes out in pure yellow needles.

0.1252g Substance gave	0.3143g CO_2;	0.0402g H_2O
Calculated for $C_{10}H_6O_3$:	C, 68.95;	H, 3.47
Found	C, 68.46;	H, 3.59

1, 8-Dihydroxynaphthalene does not yield juglone on oxida-

[5] Ber. der deutsch. chem. Gesell., 20,938 (1887).

tion. The statements of H. Erdmann[6] on its formation by means of chromic acid are erroneous. P. Friedlaender and S. Silberstern[7] obtained juglone by coupling 1, 8-aminonaphthol with diazobenzenesulfonic acid, followed by reduction and oxidation. It was suggested that 1, 8-dihydroxynaphthalene might serve as the raw material.

The formation of monoazo dyestuffs from it proceeds most smoothly in aqueous alcohol solution if less than the theoretical quantity of the diazo compound is employed. 5g Dihydroxynaphthalene are dissolved in 300cc alcohol and coupled with 2.5g diazobenzenesulfonic acid at a low temperature. After twelve hours the alcohol is boiled off and the dyestuff is salted out with a little salt. To remove any dihydroxynaphthalene it is washed with alcohol. It crystallizes from dilute alcohol in garnet red quadratic plates. It dissolves considerably in water but is difficulty soluble in alcohol.

0.2060g Substance gave 0.1398g $BaSO_4$

Calculated for $C_6H_{12}O_5N_2S$:	S, 9.32
Found	S, 9.32

The dyestuff is stirred up with much excess of sulfuric acid and zinc dust is added until it is decolorized. The filtrate which is still strongly acid is cooled and treated with an excess of ferric chloride in one portion. Juglone crystallizes out, 1.4g being obtained from 3.0g dyestuff. The product, however, was seldom pure. After recrystallization the yield usually dropped to 0.5g to 0.6g.

α- AND β-HYDROJUGLONE

α-Hydrojuglone, whether it is obtained from green walnut shells, or by the reduction of juglone or by the transformation of β-hydrojuglone, differs in one point from the statements of Mylius, for we find that the melting point of all our preparations is 148° whereas Mylius found it to be 168-70°. We do not doubt but that a satisfactory explanation of this difference will yet be found.

[6] Ann., 247,358 (1888). Also the statement in Beilstein, III, 380, that juglone according to M. Kawalski is formed from α-naphthol in alkaline solution by means of atmospheric oxygen, is incorrect. This author, Ber. 25, 1660 (1892) is describing here the ordinary hydroxynaphthoquinone.

[7] Monatsh., 23,513 (1902).

We could not confirm the statements in the literature[8] that juglone is reduced by sulfurous acid. The best method of reduction is with zinc and sulfuric acid in the following way. 5g Juglone are suspended in a separatory funnel with about 50cc ether and an under layer of 2N- sulfuric acid. Zinc dust is added in small portions, followed by vigorous shaking, until the ether layer becomes colorless, though exhibiting a strong greenish fluorescence. After removal of the ether solution, the aqueous layer and zinc dust are shaken out twice with ether. The etheral solution is dried with sodium sulfate, concentrated under diminished pressure and mixed with considerable petroleum ether. The precipitated substance did not change its melting point of 148° after reprecipitation from ether by petroleum ether or after recrystallization from water. It corresponded in its other properties to the careful description of Mylius.

0.1993g Substance gave 0.4956g CO_2 and 0.0825g H_20

Calculated for $C_{10}H_8O_3$:	C, 68.16;	H, 4.58
Found	C, 67.82;	H, 4.63

Mylius transformed it into its lower melting isomer by distillation in an atmosphere of hydrogen. It is sufficent however, as we found, to simply melt the α-compound in an evacuated flask. After keeping it in a melted condition 10 minutes in a bath at 160-70°, a yield of 70 per cent of β-hydrojuglone was obtained. It was found best to extract the cooled product with carbon tetrachloride in which the α-compound is much more completely insoluble than in chloroform. The carbon tetrachloride solution was concentrated in vacuum and the β-hydrojuglone recrystallized from alcohol or petroleum ether. It forms six sided plates, melting at 96-7°.

The transformation into the α-compound is readily carried out, as Mylius stated, by heating with alcoholic aqueous hydrochloric acid. It is also successfully obtained by dissolving the β-compound in dilute sodium hydroxide, containing a little stannous chloride, and acidfying.

[8] Ber. der deutsch. chem. Gesell., 17,1946 (1884).

SEMICARBAZONE OF β-HYDROJUGLONE

$C_{10}H_8O_2$: N. NH. CO. NH_2

Warm alcoholic solutions of β-hydrojuglone (3g in 65cc) and of semicarbazine (1.5g in 35cc) are mixed and a bottle is filled to the stopper with the solution and closed. After four days dark yellow hard globular crystals, weighing 3.8g, have crystallized out. They are washed with alcohol and recrystallized from much boiling benzene. Only one half of the product could be brought into solution, an insoluble amorphous substance remaining behind. The semicarbazone forms beautiful feather like groups of needles or sharply truncated prisms of pale yellow color which melt at 197-8° with decomposition. The compound is easily soluble in hot acetic acid, difficulty soluble in alcohol and in benzene, insoluble in ether and in ligroin.

0.1460g Substance gave 0.3062g CO_2 and 0.0650g H_20
0.1307g Substance gave 21.4cc N at 18° and 713mm
Calculated for $C_{11}H_{11}O_3N_3$: C, 56.65; H, 4.72; N, 18.03
Found C, 57.19; H, 4.98; N, 17.86

PHENYLSEMICARBAZONE OF β-HYDROJUGLONE

$C_{10}H_8O_2$: N. NH. CO. NHC_6H_5

We mixed cold saturated solutions of β-hydrojuglone (1g) and phenylsemicarbazine (1.1g) in absolute alcohol. The reaction product began to separate within a half an hour and the separation was complete in 24 hours. The phenylsemicarbazone formed a pulpy mass of bright yellow needles in star shaped groups. The yield amounted to 1.7g. By recrystallization from considerable boiling acetone (350cc required by 1g) or from xylene long thin needles were obtained which carbonized at 243° without melting.

0.1687g Substance gave 0.4090g Co_2 and 0.0744g H_2O
0.1046g 12.9cc N, dry, at 25° and 721mm
Calculated for $C_{17}H_{15}O_3N_3$: C, 66.03; H, 4.85; N, 13.59
C, 66.12; H, 4.90; N, 13.40

The phenylsemicarbazone is insoluble in ether, in alcohol

and in benzene, difficulty soluble in hot benzene. It is resolved into its components by boiling with sulfuric acid.

NOTE:—The work described in this paper was carried out in the Organic Laboratory of the Federal Polytechnic Institute, Zurich, Switzerland.

LIST OF REPTILES AND AMPHIBIANS OF NORTH CAROLINA

BY C. S. BRIMLEY

The following list is a brief summary of the records of reptiles and amphibians from North Carolina, contained in a card catalogue of the same which I have kept for a number of years. The records are drawn from the following sources:

1. Published Records. (See Bibliography at end of this paper.)

2. Specimens received by the State Museum at Raleigh, for which I am indebted to my brother, H. H. Brimley, Curator.

3. Specimens collected at various points in North Carolina by Messrs F. Sherman, H. H. Brimley, Z. P. Metcalf and myself.

4. Specimens in the Biological Laboratory of the University of North Carolina, for the pleasure of examining which I am indebted to Dr. W. C. Coker, and Dr. H. V. Wilson.

Those species of which I have not seen North Carolina specimens are marked with a star (*).

I. TAILED AMPHIBIANS (SALAMANDERS)

1. *Siren lacertina* (Great Siren). New Bern and Lake Ellis in Craven County, Edenton, Collington's Island (just north of Roanoke), apparently not common.

2. *Necturus maculatus* (Water Dog). Raleigh, Kinston, Tarboro, Chapel Hill, not common.

*3. *Necturus punctatus* (Southern Water Dog). Wilmington, two specimens sent to U. S. National Museum in March, 1882 by Donald MacRae.

4. *Amphiuma means* (Ditch Eel). Raleigh, Halifax, Clayton, Cape Hatteras, Bertie Co., Tarboro, Bladen Co., Lake Ellis, common in lowland swamps.

5. *Cryptobranchus alleghaniensis* (Hellbender). Found in the mountain streams. I have seen specimens from Cherokee and Yancey counties.

*6. *Amblystoma jeffersonianuum* (Jefferson's Salamander).

"Very numerous under logs below the fir belt on Roan Mt." S. N. Rhoads in Proceedings of Academy of Natural Sciences of Philadelphia, 1895, p. 402.

7. *Amblystoma opacum* (Marbled Salamander). Raleigh, Kinston, Tarboro, Salem, Greensboro, Chapel Hill, Lake Waccamaw, not uncommon.

8. *Amblystoma punctatum* (Spotted Salamander). Raleigh, Greensboro, Chapel Hill, and Andrews (Cherokee County).

*9. *Amblystoma talpoideum* (Mole Salamander). "Abundant in the high valley in southwestern North Carolina, in which the French Broad river takes its origin from mountain streams." Cope, Batrachia of North America, page 53.

10. *Amblystoma tigrinum* (Tiger Triton). About twenty-five received from Sanford in mid-January, 1893. A specimen without data in Biological Laboratory of State University.

11. *Diemyctylus viridescens* (American Newt). Raleigh, Chapel Hill, Kinston, Blantyre (Transylvania Co.), Highlands, Grandfather Mt., and Sunburst (Haywood Co.), Common.

*11a. *Diemyctylus viridescens vittatus* (Wilmington Newt). Wilmington (type locality), H. Garman, Journal Cincinnati Society of Natural History, 1897, pp. 49-51.

12. *Desmognathus fusca* (Brown Triton). Raleigh, Lake Ellis, Chapel Hill, Salem, Kinston, abundant.

*13. *Desmagnathus nigra* (Black Triton). Roan Mt., two adults taken by Rhoads.

14. *Desmagnathus ochrophea* (Round-tailed Triton). Abundant in the mountains mostly above 3,500 feet. Taken in Haywood, Macon, Transylvania, Buncombe, and Yancey counties and on Grandfather Mt., occuring up to at least 6,500 feet. In streams and rotten logs.

15. *Desmognathus quadrimaculatus* (Mountain Triton). Abundant in the mountains from about 3,500 feet up, in streams. Taken in Haywood, Buncombe, Yancey, Transylvania, Macon, Cherokee and on Grandfather Mountain.

*16. *Leurognathus marmoratus* (Moore's Triton). Grandfather Mountain (type locality), three taken by Dr. Moore in pool in stream on south side of mountain in July 1898. (Proc. Ac. Nat. Sc. Phila. 1899, p. 316.

17. *Plethodon erythronotus* (Red-backed Salamander). Taken by Sherman at Greenville in Pitt County, April 4, 1902. Also recorded from four mountain localities, Roan Mt., Black Mt., Andrews (Cherokee Co.), and Sunburst (Haywood Co.) Apparently not common.

18. *Plethodon glutinosus* (Viscid Salamander). Common in all parts of the state, but not apparently ranging above 3,500 feet in the mountains. Recorded from Littleton, Greenville, Raleigh, Chapel Hill, Lake Ellis, and Lumberton in the east and from the counties of Haywood, Transylvania, Buncombe, and Yancey and from Grandfather Mountain in the west.

19. *Plethodon metcalfi* (Unspotted Salamander). Common above 3,500 feet at Sunburst in Haywood County (type locality), and also on Grandfather Mountain. Two taken at Highlands and two more on the Tuskwitty Range between Andrews and Aquone in May, 1908. Occurs up to 6,000 feet at least.

20. *Plethodon shermani* (Red-legged Salamander). Taken only on the Wayah Bald Mountain, between Franklin and Aquone, (type locality). See Proc. Biol. Soc. Wash., XXV, P. 135.

21. *Manculus quadridigitatus* (Dwarf Salamander). Raleigh and Kinston, not uncommon. Terrestrial, except in the breeding season which is in January.

22. *Stereochilus marginatus* (Margined Salamander). Lake Ellis, common.

23. *Spelerpes bilineatus* (Striped Salamander). Raleigh, Salem, and in the mountains up to 5,500 feet. (Yancey, Buncombe, Haywood, Cherokee, Mitchell, Macon, and Transylvania counties and on Grandfather Mountain.)

24. *Spelerpes guttolineatus* (Holbrook's Triton). Raleigh, Salem, Andrews (Cherokee Co.), and Weaverville (Buncombe Co.) Not noted over 2,500 feet.

25. *Spelerpes danielsi* (Daniel's Triton). Blantyre (Transylvania Co.), Sunburst (Haywood Co.), and Cane River Yancey Co.), Eleven in all taken, none above 3,500 feet.

26. *Spelerpes ruber* (Red Triton). Raleigh, Goldsboro, Beaufort, Salem, Chapel Hill, Hillsboro and Summerville. Also recorded from some mountain localities, but these probably

refer to the next. Specimens from Cane River and Burnsville in Yancey county are apparently this form.

27. *Spelerpes schencki* (Black-lipped Triton). Sunburst, Blantyre, Highlands, Andrews, Wayah, Bald Mountain, and Aquone. Apparently replaces S. ruber in the mountains. Not observed above 4,000 feet elevation.

28. *Gyrinophilus porphyriticus* (Purplish Salamander). Roan Mt. (Rhoads), and Black Mt. (Sherman, larvae).

II. TAIL-LESS AMPHIBIANS (FROGS AND TOADS)

29. *Acris gryllus* (Cricket Frog). Raleigh, Lake Ellis, Chapel Hill, Greensboro, Southern Pines. Abundant.

30. *Chorophilus feriarum* (Chorus Frog). Raleigh, Greensboro, Chapel Hill, abundant. Normally commences breeding in February.

31. *Hyla cinerea* (Carolina Tree Frog). Cape Hatteras, July, 1905, (H. H. Brimley). Kinston (Cope).

32. *Hyla femoralis* (Pine woods Tree Frog). Wilmington, December 1901, Lake Ellis, May 1907 (Sherman).

33. *Hyla pickeringi* (Peeper). Occurs from Lake Ellis to the mountains. Lake Ellis, Dover, Goldsboro, Raleigh, Chapel Hill, Greensboro, Andrews, Blantyre, Toxoway, Aquone, Highlands, Black Mountain, and Roan Mt. Highest recorded elevation 6,300 feet on Roan Mountain (Rhoads).

34. *Hyla squirella* (Squirrel Tree Frog). Cape Hatteras, January 1903 (F. Sherman), Lake Ellis, July 10, 1905, (C. S. B.), and Southport, October 1906 (Sherman).

35. *Hyla versicolor* (Common Tree Frog). Raleigh, Greenville, Chapel Hill, Goldsboro, Summerville and Tarboro, common.

36. *Scaphiopus holbrooki* (Solitary Spadefoot). Raleigh, common, but seldom seen except when breeding, which happens some time in spring or summer, usually when a warm rain is falling. Have been noted breeding in March, April, May, June, and August.

37. *Bufo americanus* (Common Toad). Our only positive records are from Sunburst (Haywood Co.) and Black Mountain. Apparently the common toad of the state is the next.

38. *Bufo fowleri* (Fowler's Toad). According to Miss M. C. Dickerson, author of the "Frog Book", our Raleigh toads are this species as are also two out of three specimens from Black Mt. Chapel Hill, University collections.

39. *Bufo quercicus* (Dwarf Toad). Kinston (Cope), Beaufort (Sherman), and Lake Ellis (C. S. B.) Not common.

40. *Engystoma carolinense* (Narrow-mouthed Toad). Raleigh, Dover, Goldsboro, and Southern Pines. Breeds from May to August, common, but nocturnal and subterranean, and hence seldom seen.

41. *Rana catesbiana* (Bullfrog). Raleigh, Lake Ellis, Tarboro, Cape Hatteras, Chapel Hill, and Hendersonville.

42. *Rana clamata* (Spring Frog). Lake Ellis, Raleigh, Chapel Hill, Greensboro, Salem, Blantyre (Transylvania Co), Black Mt., Roan Mt., and Sunburst (Haywood Co).

43. *Rana palustris* (Pickerel Frog). Raleigh, Roan Mt., and Kinston. Apparently increasing in numbers at Raleigh, though not common.

44. *Rana sphenocephala* (Southern Leopard Frog). Raleigh, Lake Ellis, Cape Hatteras and Tarboro. This and *clamata* are the two commonest *Ranae* at Raleigh.

*45. *Rana sylvatica* (Wood Frog). Kinston (Cope).

46. *Rana virgatipes* (Carpenter Frog). Lake Ellis, Wilmington, the latter locality added on the authority of Mr. W. T. Davis who heard them near here in the spring of 1914.

III. LIZARDS

47. *Anolis carolinensis* (Green Lizard, "Chameleon"). Apparently common throughout the whole region east and south of Raleigh, but does not occur at Raleigh. Wilmington, Lumberton, Carthage, Southport, Smith's Id., Lake Ellis, Beaufort, Kinston, Willard (Pender Co.), Wakefield (Wake Co.), Summerville (Harnett Co.), White Lake (Bladen Co.), Albemarle (Stanly Co.), and Tryon (Polk Co.).

48. *Sceloporus undulatus* (Fence Lizard). Common, Raleigh, Chapel Hill, Lumberton, Summerville, Tarboro, Wilmington, Kinston, Salem, Blantyre (Transylvania Co.), Hendersonville, Toxoway, Franklin (Macon Co.), Andrews (Chero-

kee Co.), Black Mt., Sunburst (Haywood Co.). Does not appear to range over 3,000 feet in the mountains.

49. *Cnemidophorus sexlineatus* (Sand Lizard). Common, ranging in the mountains up to about 2,500 feet. Raleigh, Chapel Hill, Kinston, Brunswick Co., Southern Pines, Black Mt., and Andrews.

50. *Ophisaurus ventralis* (Glass Snake). Chapel Hill, Raleigh, Garner (Wake Co.), Southport, Beaufort, Wilmington, New Bern, Washington, White Lake (Bladen Co.), and Statesville. Confined mainly to the eastern part of the state, not common.

51. *Leiolepisma laterale* (Ground Lizard). Raleigh, Lake Ellis, Chapel Hill, Kinston, Salem, not uncommon, but secretive in habits.

52. *Eumeces quinquelineatus* (Bluetailed Lizard, "Scorpion"). Raleigh, Chapel Hill, Lumberton, Lake Ellis, Kinston, New Bern, Blantyre, Andrews, Franklin, ranging up to 3,000 feet at least.

IV. HARMLESS SNAKES

53. *Abastor erythrogrammus* (Rainbow Snake). New Bern, Wilmington, Kinston, Lake Ellis, Edenton, not common.

54. *Bascanium constrictor* (Black Snake). Raleigh, Chapel Hill, Lake Ellis, Washington, Statesville, Blantyre and Black Mountain. Common.

55. *Bascanium flagellum* (Coach whip). Southern Pines, Lake Ellis, White Lake (Bladen Co.), and Pender Co., one specimen from each locality.

56. *Carphophiops amoenus* (Worm Snake). Lake Ellis, Raleigh, Chapel Hill, Washington, Kinston, Blantyre, Andrews, and Sunburst. Common in rotten stumps and logs.

57. *Cemophora coccinea* (Scarlet Snake), Raleigh, Southern Pines, Washington, not common, in the eastern part of the state only.

58. *Coluber guttatus* (Spotted Racer; Corn Snake). Eastern part of state, not common. Raleigh, Washington, Lake Ellis, Southern Pines.

59. *Coluber obsoletus* (Black Chicken Snake). Western

two thirds of state, not uncommon. Raleigh, Chapel Hill, Kinston, Taylorsville, Andrews (Cherokee Co.), Sunburst (Haywood Co.)

60. *Coluber quadrivittatus* (Stripped Chicken Snake). Eastern part of state. New Bern, Cape Hatteras, Lake Ellis, Pender Co., Maysville (Jones Co.), White Lake (Bladen Co.)

61. *Cyclophis aestivus* (Southern Green Snake), Common, arboreal, on low bushes and coarse herbage. Bertie Co., Tarboro, Kinston, Beaufort, Cape Hatteras, Southern Pines and Chapel Hill.

62. *Diadophis punctatus* (Ring-necked Snake). Apparently whole state, common. Lake Ellis, Raleigh, Chapel Hill, Summerville, Blantyre (Transylvania Co.), and Sunburst.

63. *Eutaenia saurita* (Ribbon Snake). Wilmington, Raleigh, Avoca, Summerville, and Toxoway.

64. *Eutaenia sirtalis* (Garter Snake). Raleigh, Chapel Hill, Kinston, Jackson, (Northampton Co.), Cane River (Yancey Co.), and Sunburst. Common.

65. *Farancia abacura* (Horn Snake). Eastern section only. New Bern, Wilmington, Whiteville (Columbus Co.), Currituck, White Lake, and Lake Ellis.

66. *Haldea striatula* (Ground Snake). Raleigh, Summerville, Lumberton, Bertie Co., Lake Ellis. Common.

67. *Heterodon platyrhinus* (Spreading Adder). Wilmington, Goldsboro, Kinston, Beaufort, Chapel Hill, Raleigh, Summerville, Southern Pines, Washington, and Black Mountain, also Statesville. Common. Black specimens are occasional.

68. *Heterodon simus* (Hog-nosed Snake). Goldsboro, Lake Ellis, and Wake Co., not common.

69a. *Natrix fasciata fasciata* (Southern Water Snake). Eastern section, less common than the next. New Bern, Wilmington, Lake Ellis, and Raleigh.

69b. *Natrix fasciata sipedon* (Northern Water Snake). The common water snake of the whole state. Wilmington, Kinston, Cape Hatteras, Goldsboro, Royal Shoals (Pamlico Sound) White Lake, Washington, Salem, Black Mountain, Cane River, Sunburst, Andrews, Raleigh and Chapel Hill.

69c. *Natrix fasciata erythrogastra* (Red-bellied Water

Snake, "Copperbelly"). Not common, Kinston, Lake Ellis, Raleigh, White Lake, Jackson (Northampton Co.).

70. *Natrix taxispilota* (Pied Water Snake), Kinston, Avoca, Lake Ellis, White Lake, New Bern, Cape Hatteras, and Pender Co. Common in the east.

71. *Natrix leberis* (Willow Snake, Queen Snake). Raleigh, Chapel Hill, Kinston, Waynesville, Blantyre, Cane River. Not common.

72. *Ophibolus doliatus coccineus* (Red King Snake) Summerville, Chapel Hill, Raleigh, not uncommon.

73. *Ophibolus doliatus triangulus* (Milk Snake). Sun burst (Haywood Co.), two specimens.

74. *Ophibolus getulus* (King Snake). Raleigh, Chapel Hill, Lake Ellis, New Bern, Kinston, Washington, Brunswick Co., Homestead (Graham Co.), Patterson (Caldwell Co.), Blantyre (Transylvania Co.) Common.

75. *Ophibolus rhombomaculatus* (Brown King Snake). Raleigh, Chapel Hill, Jackson, Washington, Statesville. Not common.

76. *Pityophis melanoleucus* (Pine Snake, Bull Snake). Two received alive by State Museum from Bushnell, Swain Co., in August 1909.

*77. *Rhadinaea flavilata* (Brown-headed Snake). Fort Macon (Cope).

78. *Storeria dekayi* (DeKay's Snake). Raleigh, Chapel Hill, Kinston, and Cherokee. Common.

79. *Storeria occipitomaculata* (Red-bellied Storeria). Raleigh, Southern Pines, Chapel Hill, Cranberry. Less common than preceding.

80. *Virginia valeriae* (Valeria's Snake). Raleigh, Chapel Hill, Statesville, and Andrews. Not common.

V. POISONOUS SNAKES

81. *Tantilla coronata* (Crowned Tantilla). Raleigh, May 6, 1906, Southern Pines, May, 1909, also a specimen in the Zoological Laboratory of the University of North Carolina without data, possibly from Beaufort. Our only Dipsadine snake.

82. *Elaps fulvius* (Coral Snake) Montrose, Hoke Co., July 29, 1912, specimen killed and sent to State Museum by Dr. M. E. Street.

83. *Ancistrodon contortrix* (Copperhead). Wilmington, Lake Ellis, Raleigh, Chapel Hill, Jackson Co., Montreat. Not uncommon.

84. *Ancistrodon piscivorus* (Cottonmouth). Eastern Section. New Bern, Lake Ellis, Wilmington, Cape Hatteras, Washington, Beaufort, Whiteville, Raleigh.

85. *Crotalus adamanteus* (Diamond Rattlesnake). Jackson (Cope), Havelock (Craven Co.), and Pender Co. (J. A. Holmes), near the coast only.

86. *Crotalus horridus* (Banded Rattlesnake). Wilmington, New Bern, Dare Co., Lake Ellis, Beaufort, and in the mountains from Cherokee, Macon, Buncombe, Haywood, and Alexander counties.

*87. *Sistrurus miliarius* (Ground Rattlesnake). Wilmington, (Cope), Bogue and Shackleford's Banks (Coues 1871).

VI. TURTLES

88. *Terrapene carolina* (Box Tortoise, Highland Terrapin). Raleigh, Chapel Hill, Beaufort, Lake Ellis, Greensboro.

89. *Chelopus guttatus* (Speckled Terrapin). Raleigh, Beaufort, Lake Ellis, Southern Pines.

*90. *Chelopus muhlenbergi* (Muhlenberg's Terrapin). Three specimens taken October 1879, by A. L. Barringer at Statesville, (Yarrow in Check List).

91. *Malaclemmys centrata* (Diamond-back Terrapin). Salt marshes along the coast only. Beaufort, Brunswick, Carteret, Dare, New Hanover, Onslow, Pasquotank, Pamlico, Pender, Craven, and Hyde counties.

*92. *Deirochelys reticulata* (Chicken Turtle). "North Carolina to Florida inclusive" Ditmars in Reptile Book.

93. *Chrysemys picta* (Painted Terrapin). Raleigh, Chapel Hill, Greensboro, the most abundant turtle at the former place.

94. *Pseudemys concinna* (River Terrapin). Raleigh, and Tarboro, less common than in previous years at the former

place. Also two nearly hatched specimens, without data, in the Zoological Laboratory of University of North Carolina.

95. *Pseudemys floridana* (Florida Terrapin). Lake Ellis, also Richardson's Pond in Johnston Co.

96. *Pseudemys mobilensis* (Mobile Terrapin). A specimen 13 inches long in shell from White Lake, Bladen Co., doubtfully referred here.

*97. *Pseudemys rubriventris* (Red-bellied Terrapin). Specimens in U. S. National Museum from Kinston and Wilmington according to Yarrows Check List of North American Reptiles and Batrachians, 1883.

98. *Pseudemys scripta* (Yellow-bellied Terrapin). Raleigh and Lake Ellis, common, also recorded from Beaufort and Greensboro. Has apparently much increased in numbers at Raleigh of late years.

99. *Pseudemys troostii* (Troost's Terrapin). Raleigh, November 1914, one speciment 8 inches in shell.

100. *Cinosternum pennsylvanicum* (Mud Turtle). Tarboro, Raleigh, Chapel Hill, and Beaufort. Abundant.

101. *Aromochelys odoratus* (Musk Turtle). Raleigh, Lake Ellis, Greensboro. Less common and much more aquatic than the preceding.

102. *Chelydra serpentina* (Snapping Turtle). Raleigh, Chapel Hill, Lake Ellis, Beaufort.

*103. *Colpochelys kempi* (Kemp's Loggerhead, "Hawksbill"). Beaufort and Cape Hatteras.

104. *Thalassochelys caretta* (Loggerhead Sea Turtle), Beaufort and Pamlico Sound.

*105. *Chelone mydas* (Green Sea Turtle) Beaufort, rare.

106. *Dermochelys coriacea* (Leatherback Sea Turtle). Beaufort, May 27, 1897.

VII. CROCODILIANS

107. *Alligator mississippiensis* (Alligator). Brunswick, Craven, Carteret, Bladen, New Hanover, Onslow, and Robeson counties.

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